Doc 9710, VAP/13

INTERNATIONAL CIVIL
AVIATION ORGANIZATION

VISUAL AIDS PANEL

THIRTEENTH MEETING

Montreal, 9-20 June 1997

REPORT

Developed by the Visual Aids Panel and issued by authority of the Air Navigation Commission.

The views expressed in this report should be taken as advice of a panel of experts to the Air Navigation Commission but not as representing the views of the Organization.

The Supplement to the report indicates the action taken on the report by the Air Navigation Commission.

MONTREAL 1998

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INTERNATIONAL CIVIL AVIATION ORGANIZATION

THIRTEENTH MEETING OF THE VISUAL AIDS PANEL (VAP)

Montreal, 9 to 20 June 1997

SUPPLEMENT NO. 1

1. The Air Navigation Commission, at the first, second and third meetings of its 147th Session on 22, 27 and 29 January 1998, respectively, under authority delegated by the Council, took action on the recommendations of the thirteenth meeting of the Visual Aids Panel (VAP/13), as indicated hereunder.

2. **RECOMMENDATIONS FOR AMENDMENT OF STANDARDS AND RECOMMENDED PRACTICES AND PROCEDURES (RSPP)**

2.1 Recommendation 1/1, page 1-30
Recommendation 1/2, page 1-30
Recommendation 1/3, page 1-30
Recommendation 1/4, page 1-30
Recommendation 2/1, page 2-9
Recommendation 3/1, page 3-9
Recommendation 4/1, page 4-13
Recommendation 4/2, page 4-13
Recommendation 5/2, page 5-6

2.2 The Air Navigation Commission made a preliminary review of the above recommendations and agreed that, with the exception of Recommendations 1/2 and 1/3, they should be referred for comments to Contracting States and appropriate international organizations, together with the Commission's own comments and proposals thereon. Following receipt of comments, the Commission will conduct a detailed review and will then present its recommendations for action by the Council.

3. **RECOMMENDATIONS OTHER THAN FOR STANDARDS AND RECOMMENDED PRACTICES AND PROCEDURES (RSPP)**

3.1 The Secretary General will arrange for any follow-up action in respect of all approved recommendations as indicated in the action taken hereunder.

Report Reference		Action by Council (C) or Air Navigation Commission (ANC)	Recommendation Title and Action Taken
Recommendation No.	Page No.		
1/5	1-30	ANC	**Amendment to the *Aerodrome Design Manual*, Part 4 — *Visual Aids* (Doc 9157)** Approved the recommendation and requested the Secretary General to revise the manual.
1/6	1-31	ANC	***ACI/IATA Apron Markings and Signs Handbook*** Approved the recommendation and requested the Secretary General to take appropriate action.
1/7	1-31	ANC	**Land and hold short operations** Approved the recommendation and requested the Secretary General to take appropriate action.
1/8	1-31	ANC	**Operational requirements for land and hold short operations** Approved the recommendation and requested the Secretary General to take appropriate action.
1/9	1-31	ANC	**Variable message signs** Approved the recommendation and requested the Secretary General to ensure that this task would be included in the new VAP work programme.

Report Reference		Action by Council (C) or Air Navigation Commission (ANC)	Recommendation Title and Action Taken
Recommendation No.	Page No.		
1/10	1-31	ANC	**Visual aids for A-SMGCS** Noted the recommendation and its relationship to Recommendation 6/4.
2/2	2-10	ANC	**Protection date for aerodrome lighting systems** Approved the recommendation and requested the Secretary General to take appropriate action.
2/3	2-10	ANC	**The *Aerodrome Design Manual*, Part 5 — *Electrical Systems* (Doc 9157)** Approved the recommendation and requested the Secretary General to take appropriate action.
2/4	2-10	ANC	**Updating of the *Aerodrome Design Manual*, Part 5 — *Electrical Systems* (Doc 9157)** Approved the recommendation and noted that this task would be undertaken in co-operation with the International Electrotechnical Commission (IEC).
4/3	4-14	ANC	**Modification of approach and runway lighting configurations** Noted the recommendation and its relationship to Recommendation 6/4.
5/1	5-6	ANC	**1996 CIE chromaticity diagram** Approved the recommendation and requested the Secretary General to monitor developments and take action as appropriate in due course.

Report Reference		Action by Council (C) or Air Navigation Commission (ANC)	Recommendation Title and Action Taken
Recommendation No.	Page No.		
5/3	5-6	ANC	**Amendment to the *Aerodrome Design Manual*, Part 4 — *Visual Aids* (Doc 9157)** Approved the recommendation and requested the Secretary General to revise the manual.
6/1	6-10	ANC	**Visual alignment guidance system for heliports** Approved the recommendation and agreed to delete ANC Task No. AGA-7701 from the Technical Work Programme (TWP) of the Organization in the Air Navigation Field.
6/2	6-10	ANC	**Visual alignment guidance system for runways** Approved the recommendation and noted that ANC Task No. AGA-9402 had already been deleted from the TWP.
6/3	6-10	ANC	**Switching of lighting aids** Noted the recommendation and the intent of the Secretary General to propose an appropriate task for inclusion in the TWP.
6/4	6-10	ANC	**Future of the Visual Aids Panel** Agreed that the panel should continue and approved the proposed new VAP work programme.

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LETTER OF TRANSMITTAL

To: The President, Air Navigation Commission

From: The Chairman, Thirteenth Meeting of the Visual Aids Panel (VAP)

I have the honour to submit the report of the thirteenth meeting of the ICAO Visual Aids Panel (VAP) held in Montreal from 9 June to 20 June 1997.

N. Berry

N. Berry
Chairman

Montreal, 20 June 1997

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LIST OF RECOMMENDATIONS*

* Recommendations annotated "RSPP" relate to proposals for amendment of Standards, Recommended Practices, procedures for air navigation services or guidance material in an Annex.

VISUAL AIDS PANEL

REPORT OF THE THIRTEENTH MEETING

Montreal, 9 to 20 June 1997

PART I — ORGANIZATION OF THE MEETING

1. DURATION

1.1 The thirteenth meeting of the Visual Aids Panel (VAP) was held at the ICAO Headquarters in Montreal. It was opened by the Vice President of the Air Navigation Commission, Mr. R.W.I. Allison, at 1100 hours on 9 June 1997. The meeting finished on 20 June 1997.

2. ATTENDANCE

2.1 The meeting was attended by members nominated by eleven Contracting States and four international organizations, by advisers and other participants as shown in the following list:

Member	Advisers	Nominated by
Sullivan, B.N.		Australia
van den Broeck, L.F.E.	Vandevoorde, J.-C.	Belgium
Berry, N.	Alf, E. Héneault, G. Wilson, M.J.	Canada
Tanguy, J.	Moal, P.-Y. Verdier, B.	France
Noichi, K.	Handa, K. Hondo, K. Sugasawara, N.	Japan
Franssen, A.L.	Meerman, H.E.	Netherlands, Kingdom of the
Klenin, Y.F.*	Gorshkov, V.N. Ivanov, A.N. Lysenko, I.M.	Russian Federation

* Temporary replacement member

Member	Advisers	Nominated by
Balcells Serra, F.		Spain
Eriksson, N.G.		Sweden
Cargill, N.S.	Galyer, P. Smith, A.J. Wong, E.M.C.	United Kingdom
Lewis, E.	Jones, P.H. Person, A.	United States
Massot, J.-N.	Gamper, D.B. Heitmeyer, R.	ACI
	Woodhouse, R.	IATA
Moore, M.		IFALPA
Tansley, B.W.		CIE

Others

Borda, M.

Khalil, M.H.

Lampi, M.N.

3. Officers and Secretariat

3.1 Mr. N. Berry was elected Chairman and Mr. B.N. Sullivan Vice-Chairman of the meeting.

3.2 The Secretary of the meeting was Mr. M. Nygards, Technical Officer of the Aerodromes, Air Routes and Ground Aids Section. Mr. A.K.R. Rao, Acting Chief of the same section also participated in the meeting. Mr. R.T. Slatter, Consultant, Operations/Airworthiness Section, Mr. T. Imagome, Technical Officer, Air Traffic Management Section and Mr. V. Iatsouk, Technical Officer, Communication, Navigation and Surveillance Section provided advice to the meeting as required.

3.3 Interpretation and translation in English, French, Spanish and Russian were provided by the Language Branch under the direction of Mr. Y.N. Beliaev.

4. Agenda of the Meeting

4.1 The agenda for the meeting shown hereunder was approved by the Air Navigation Commission on 26 November 1996 ANC (143-9):

Agenda Item 1:	Visual aids for surface movement guidance and control
Agenda Item 2:	Secondary power supply and design
Agenda Item 3:	Obstacle lighting
Agenda Item 4:	Reduced lighting for precision approach runways
Agenda Item 5:	Measurement of light intensity/aeronautical ground lights
Agenda Item 6:	Future work

5. Working Arrangements

5.1 The panel met as a single body with *ad hoc* drafting groups as required. Discussions in the meeting were conducted in English, French, Russian and Spanish. The report was issued in English, French, Russian, and Spanish.

6. Terms of Reference

6.1 To undertake specific studies, as approved by the Air Navigation Commission and reflected in the work programme of the panel, with a view to advising the Commission on technically practical and operationally feasible ICAO provisions, as necessary, to meet the objectives specified in the work programme.

7. Work Programme

7.1 On 20 June 1995, the Air Navigation Commission approved the revised work programme of the panel as follows:

ANC Task No.	Work Programme Item	Estimated Completion Date
AGA-7701	1) **Visual aids for heliports** Develop specifications for a standard visual alignment guidance system.	1997

ANC Task No.	Work Programme Item	Estimated Completion Date
AGA-7801	2) **Visual aids for surface movement guidance and control** a) Further development of specifications for runway guard lights, i.e. establishment of a day time intensity. b) Evaluation of the adequacy of the dimensions specified in Annex 14, Volume I for taxi-holding position markings. c) Development of specifications on visual aids for simultaneous operations on intersecting runways. d) Development of specifications on fibre-optic signs and addressable signs. e) Development of specifications on mandatory instruction markings. f) Improving the clarity of Annex 14, Volume I, paragraphs 5.3.15.1 to 5.3.15.3. g) Improving the conspicuity of markings through the use of retro-reflective paint. h) Lighting of holding positions established on taxiways at locations other than taxiway/taxiway intersections. i) Appropriateness of renaming "taxiway intersection lights" as "clearance bars".	1997
AGA-8801	3) **Secondary power supply and design** a) Lighting requirements for take-off runways used in RVRs greater than 800 m and provision of appropriate secondary power. b) Development of a definition for the term "1 second switch-over time". c) Updating the *Aerodrome Design Manual*, Part 5 — *Electrical Systems* (Doc 9157). d) Secondary power supply requirements for Category I operations over hazardous or precipitous terrain.	1997

ANC Task No.	Work Programme Item	Estimated Completion Date
AGA-8804	4) **Obstacle lighting** An over-all review and update of the specifications on obstacle lighting to be displayed on fixed objects, with the view to: a) ensuring that the specifications include lights appropriate for different visibility and operating conditions; and b) overcoming the environmental problems associated with the use of flashing lights by night, particularly the high-intensity flashing-white obstacle lights.	1997
AGA-9205	5) **Measurement of light intensity** Development of standard procedures for the measurement of intensities of steady burning and flashing lights.	1997
AGA-9202	6) **Visual aids for advanced surface movement guidance and control systems (A-SMGCS)** a) Study the development of A-SMGCS. b) Co-ordinate the parallel development of visual aids to meet the requirements of such systems. c) Develop specifications where necessary for visual aids to control movements on airports in response to A-SMGCS. d) Upgrade the current specifications for visual aids to ensure compatibility with the requirements of A-SMGCS.	1998
AGA-9206	7) **Reduced lighting for precision approach runways** a) Study of the possibility of reducing the patterns of lighting currently specified in Annex 14, Volume I for precision approach runways Categories II and III. b) Study the impact of reduced lighting on the characteristics of touchdown zone marking.	1997

ANC Task No.	Work Programme Item	Estimated Completion Date
	c) Study the possibility of specifying a single pattern of touchdown zone marking.	
AGA-9402	8) **Visual alignment guidance system for runways** Develop a visual aid to provide alignment guidance to a runway where it is physically impossible to install an approach lighting system.	1997
AGA-9504	9) **Colours for aeronautical ground lights** a) Review and update the Annex 14, Volume I specifications on colours of lights using dyed-in-mass filters. b) Develop specifications on colours of lights using dichroic filters.	1997
AGA-9505	10) **De/anti-icing pads** Develop specifications on marking and lighting.	1997

8. Opening remarks by the Vice President of the Air Navigation Commission

Ladies and Gentlemen,

On behalf of the Air Navigation Commission, it is a pleasure to welcome you all to Montreal, to ICAO and to the thirteenth meeting of the Visual Aids Panel. There have been a number of changes in the membership of the panel since your last meeting and to these new members I extend a special welcome. The panel, I am sure, will look forward to your contributions.

Since your last meeting in September/October 1991, the Air Navigation Commission has progressed a number of issues in your area. Allow me to mention some of the more important ones.

On 13 March 1995, the ICAO Council adopted Amendment 1 to Annex 14, Volumes I and II. This amendment, which became applicable on 9 November 1995, included several new and revised specifications related to visual aids based on material developed by the VAP/12 Meeting.

Since technical or financial difficulties in implementing some of the new specifications by 9 November 1995 were cited, the Commission agreed to allow additional time to implement the new provisions related to aiming point marking, touchdown zone marking and information signs. However, as regards mandatory instruction signs, the Commission considered that, as they were safety-related, existing signs not meeting the new specifications should be replaced by 9 November 1995.

The Commission re-examined the need to restrict, in runway visual range conditions less than a value of 550 m, the number of aircraft on the manoeuvring area to one, at any time, where stop bars were not provided and agreed to recommend that such restriction should apply only where appropriate aids and procedures were not available to assist in preventing inadvertent incursions of aircraft and vehicles onto the runway.

With respect to emergency vehicles, the Commission endorsed the suggestion of the panel that the signal of obstacle lights displayed on them should be changed, from flashing-red to flashing-blue, to enable emergency vehicles to be distinguished from aircraft, which are equipped with flashing-red anti-collision lights. On the other hand, the Commission referred back to the panel the bulk of the amendment proposals related to obstacle lighting. It was not considered advisable to extend the use of flashing-white obstacle lights until the environmental concerns associated with their use at night had been further studied.

The Commission agreed to the proposal for amendment of Annex 14, Volume I developed by the panel with the objective of extending the applicability of lighting aids currently specified for precision approach runways to basic MLS operations.

In this context, I would like to draw your attention to one issue which should be of particular interest to the panel. The Commission requested the Secretariat to harmonize the definitions of precision approach runways with the amendments to Annex 6, Parts I and II, being developed to incorporate the new classification of instrument approach and landing operations. The proposed revised definitions developed by the Secretariat were transmitted to States and interested international organizations for comment and subsequently incorporated in the Second Edition of Annex 14, Volume I.

You may recall that, while recommending the inclusion of specifications on PAPI, the AGA Divisional Meeting in 1981 had agreed that the use of VASIS should be terminated on 1 January 1995. To this end, the ANC reviewed the results of a world-wide survey undertaken by the Secretariat on the status of different types of visual approach slope indicator systems in use. A proposed amendment developed with the view to deleting the specifications on VASIS was, after consultation with States and international organizations, incorporated in the Second Edition of Annex 14, Volume I.

You will be aware that in 1992 the Commission agreed, in principle, to disband the panel after the VAP/13 Meeting and directed the panel to complete the work programme at this meeting. While recognizing that additional items have been added to the work programme since then, the Commission appreciates the efforts you have made during the past years to meet that objective. The Commission has been advised that much preparatory work has been done, either through working groups or by correspondence, on the work programme items to be discussed at the meeting.

As always, the current work programme of the panel covers a broad range of issues. Lately, the tasks related to advanced surface movement guidance and control systems (A-SMGCS) have assumed particular importance in view of the capacity constraints at several airports and the inherent potential of such systems to improve the airport capacity. In this context, you will be pleased to know that, at the next meeting of the All Weather Operations Panel (AWOP) in July this year, Draft Operational Requirements for Advanced Surface Movement Guidance and Control Systems will be presented for review, and it is envisaged that the AWOP will recommend adoption of these operational requirements for worldwide application. The Commission will, therefore, with great interest review the results of your work, so far, in this area.

The results of the panel's study of the possibility of reducing the patterns of lighting currently specified for precision approach runways categories II and III will also be of particular interest. It is recognized that the panel may encounter some reluctance to propose changes to lighting systems that are generally perceived as being operationally satisfactory. Let me, however, assure you that it is not in the interest of the aviation industry to retain standards that could, without degrading safety, be replaced by less demanding ones.

I mentioned earlier that the Commission had referred back to the panel the task of updating the Annex 14, Volume I specifications related to obstacle lighting with the view to overcoming the environmental problems associated with the use of flashing lights at night, particularly the flashing-white lights. Any efforts by this panel of experts to make it possible to resolve this problem at this meeting, taking into account current State practices, will be much appreciated.

I wish to remind you that, in accordance with the *Directives for Panels of the Air Navigation Commission* (Doc 7984), you, as panel members, participate in the meeting in a personal expert capacity representing your own professional views, which may not necessarily be the same as those of your nominating administrations or organizations. Thus, your contributions do not in any way commit your State or organization.

Before closing the meeting, you may wish to make proposals in a structured approach for tasks related to visual aids on which further work would need to be undertaken in the immediate future, such as development of new visual aids in response to A-SMGCS and to recommend alternative courses for accomplishing these future tasks. I can assure you that the Air Navigation Commission will review these proposals with due consideration.

A debriefing session with the Air Navigation Commission will be scheduled at the end of the meeting. In that session, we would like the chairman of this meeting to highlight the work that has been accomplished during the meeting, any major difficulties you may have identified to progress your work as well as the proposed future work. You are all invited to participate in the debriefing.

You have a considerable amount of work to accomplish during the next ten days. The Commission is confident that you will complete all your agenda items and achieve the goals established for this meeting. Should you require any advice or assistance in your work, I trust that your chairman will not hesitate to call upon me, any member of the Commission, the Director of the Air Navigation Bureau or any other member of the Secretariat.

I wish you every success in your deliberations and declare open the thirteenth meeting of the Visual Aids Panel.

9. GLOSSARY OF TERMS

A

ACI	Airports Council International
ADSG	Airport Design Study Group
AGL	above ground level
AIP	Aeronautical Information Publication
ALSF	approach lighting system with sequenced flashing lights
ANC	Air Navigation Commission
A-SMGCS	advanced surface movement guidance and control systems
ATC	air traffic control
ATIS	automatic terminal information service
AVOL	aerodrome visibility operational level
AWOP	All Weather Operations Panel

C

Cd	candela
CIE	International Commission on Illumination (Commission Internationale de l'Éclairage)

D

DRA	United Kingdom Defense Research Agency
DH	decision height

E

EANPG	European Air Navigation Planning Group

F

FAA	Federal Aviation Administration
FATO	final approach and take-off area
FPM	flashes per minute

G

GNSS	global navigation satellite system
GPS	global positioning system

H

HIRL	high intensity runway lighting

I

IATA	International Air Transport Association
IEC	International Electrotechnical Commission
IFALPA	International Federation of Air Line Pilots' Associations
IFR	instrument flight rules
ILS	instrument landing system

J

JAA	Joint Aviation Authority

L

LAHSO	land and hold short operations

M

MDA	minimum descent altitude
MLS	microwave landing system

N

NOTAM	notice to airmen

O

ODALS	simplified approach lighting system

P

PANS-OPS	Procedures for Air Navigation Services - Aircraft Operations
PANS-RAC	Procedures for Air Navigation Services - Rules of the Air and Air Traffic Services
PAPI	precision approach path indicator system

R

RETILs	rapid exit taxiway indicator lights
RVR	runway visual range

S

SIMOPS	simultaneous operations
SIRO	simultaneous intersecting runway operations
SMGC	surface movement guidance and control
SOIR	simultaneous operations on parallel or near-parallel instrument runways; or simultaneous operations on intersecting runways

T

TORA	take-off run available

V

VAP	Visual Aids Panel
VASIS	visual approach slope indicator system
VFR	visual flight rules

W

WG	working group

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PART II — REPORT ON AGENDA ITEM 1

Agenda Item 1: Visual aids for surface movement guidance and control

1.1 INTRODUCTION

1.1.1 The purpose of this agenda item was to further develop the Annex 14, Volume I specifications on visual aids for surface movement guidance and control (SMGC) as well as to develop specifications on visual aids in response to advanced surface movement guidance and control systems (A-SMGCS). In this context, it should be noted that the Commission had agreed that the meaning of the "A" in A-SMGCS should be changed from "automated" to "advanced".

1.1.2 The VAP/10 Meeting (1984) considered that an overall review and refinement of the visual aids for SMGC specified in Annex 14, placing special emphasis on the requirements of operations in limited visibility conditions, was essential to preclude collisions on the ground. This view was endorsed by the Air Navigation Commission and the subject was added to the work programme of the panel. As a result, the panel agreed to set up a working group, known as the Working Group on Visual Aids for SMGC, to accomplish this task. The task was partly resolved at the VAP/11 and VAP/12 Meetings (1987 and 1991) and the proposed amendments developed at those meetings have since been incorporated into Annexes 2, 4 and 14, respectively.

1.1.3 The task is currently included in work programme Item 2 — Visual aids for SMGC. Five new issues were added to the work programme item after the Commission's final review of the proposals for amendment of Annex 14, Volume I stemming from the recommendations of VAP/12.

1.1.4 The working group resolved the luminance levels of taxiing guidance signs and the characteristics of runway vacated signs prior to the Commission's final review of the VAP/12 proposals for amendment of Annex 14, Volume I. Consequently, the Second Edition of Annex 14, Volume I incorporated the results of VAP's work on these issues.

1.1.5 The VAP/12 Meeting recommended that ICAO task an appropriate body of visual aids experts to:

a) study the development of A-SMGCS;

b) co-ordinate the parallel development of visual aids to meet the requirements of such systems;

c) develop specifications, where necessary, for visual aids to control movements on airports in response to A-SMGCS; and

d) upgrade the current specifications for visual aids to ensure compatibility with the requirements of A-SMGCS.

1.1.6 The Commission approved the recommendation and assigned the task of standardizing the visual aids component of A-SMGCS to the VAP. Subsequently, the panel agreed that this task should also be handled by the Working Group on Visual Aids for SMGC. The task is currently included in work programme Item 6 — Visual aids for A-SMGCS. As for the non-visual aids components and procedures associated with A-SMGCS, the Commission requested the Secretariat to monitor developments and to submit proposals when it was timely to address those aspects.

1.1.7 At the sixth meeting of the working group, a sub-group was established to develop proposals for the visual aids components of A-SMGCS. The sub-group undertook the task of assessing all the visual aids specified in Annex 14, Volume I to determine which aids would likely form components of an A-SMGCS. The sub-group then determined which of these aids would be suitable in their present form and which would require modification to facilitate introduction of A-SMGCS. Finally, the sub-group directed its attention to new visual aids that may possibly be necessary in an A-SMGCS.

1.1.8 The Working Group on Visual Aids for SMGC met six times after VAP/12 and the results of its work, which included proposals for amendments to Annex 14, Volume I, PANS-RAC and PANS-OPS, Volume II as well as guidance material proposed for inclusion in the *Aerodrome Design Manual*, Part 4 — *Visual Aids* (Doc 9157), were presented at the meeting.

1.2 VISUAL AIDS FOR SMGC

1.2.1 The meeting reviewed and refined the amendment proposals related to visual aids for SMGC and the results are reflected in Appendices A, B and C to the report on this agenda item. The meeting also reviewed and refined the associated guidance material proposed for inclusion in the *Aerodrome Design Manual*, Part 4 and the results are reflected in Appendix F to the report on this agenda item. The following paragraphs detail the more significant issues discussed and conclusions reached.

1.2.2 Measuring the average luminance level of a conventional sign

1.2.2.1 The Second Edition of Annex 14, Volume I had incorporated specifications on luminance levels of taxiing guidance signs (paragraph 1.1.4 above refers). However, guidance on how to verify compliance with these specifications had not been developed.

1.2.2.2 The working group had been advised that several States had already developed or were in the process of developing guidance on this issue. The working group was presented with the details of a system developed in Canada, which used a digital camera to record photometric data in pixels of the captured image. This data was then displayed and analysed using an appropriate software. The system could be used either in the laboratory or in the field. Based on this system, a procedure for conducting *in situ* measurements of fibre-optic signs had been developed. This could be extended to conventional signs as well.

1.2.2.3 The United Kingdom procedure envisaged the establishment of grid points at 15 cm intervals along the sign face. However, no grid points were located within a 7.5 cm wide strip along the borders of the sign. Furthermore, when the average luminance level of a letter of an internally lit sign was measured, a minimum of five grid points were located on each letter.

1.2.2.4 One of the reasons for developing guidance on measuring the average luminance level of a sign was to be able to ensure compliance with performance requirements over time. To this end, one member of the working group recommended the use of a digital photometric image analysis system. It was considered that such a system would provide an excellent capability to evaluate luminance degradation over time compared to pre-installation performance. The working group, however, considered that a digital system provided a level of sophistication that would not generally be required and suggested that primarily it was necessary to have a basic evaluation method documented. It was also pointed out that the ICAO specifications were intended for worldwide use and should not be too complicated. The working group, therefore, developed a method of measurement of both luminance and colour co-ordinates using spot readings at points on the sign face defined by a regular grid. The working group also developed guidance material on the measuring procedures for inclusion in the *Aerodrome Design Manual*, Part 4.

1.2.2.5 In this context, the meeting was apprised of an evaluation performed on a trans-illuminated taxiing guidance sign to compare the photometric performance of the sign when using a 15 cm grid and a 7.5 cm grid. It had been found that the 15 cm grid proved more effective in highlighting areas where there was a drop in luminance levels. For the 7.5 cm grid to be as effective, the ratio of luminance levels between adjacent points must be reduced to 1:1.25. Thus, it was concluded that there was no particular advantage of using a 7.5 cm grid, which would require four times as many data points when compared to using a 15 cm grid.

1.2.2.6 Furthermore, since the characters and numerals included in Annex 14, Volume I, Appendix 4 did not represent a particular font, the working group had recommended that an additional table defining character dimensions and spacings be included in Annex 14, Volume I, Appendix 4.

1.2.2.7 The meeting endorsed the proposed method of measurement developed by the working group. The meeting also endorsed the related proposal for amendment to Annex 14, Volume I, Appendix 4 with minor modifications.

1.2.2.8 The meeting further saw the need to supplement the guidance material developed by the working group for inclusion in the design manual with additional guidance on the application of the proposed table defining character dimensions and spacings including determination of the face width of a sign.

1.2.3 Modification of the term "taxi-holding position"

1.2.3.1 At its eighth meeting, the working group had noted that the term "taxi-holding position" was probably not an accurate description of a point intended to protect a runway or its specific environs and that the term was easily confused. The definition of the term "taxi-holding position", was amended in the Second Edition of Annex 14, Volume I to read as follows:

> "A designated position at which taxiing aircraft and vehicles shall stop and hold position, unless otherwise authorized by the aerodrome control tower."

1.2.3.2 The issue was further discussed at subsequent meetings of the working group. The following points had been raised:

a) pilots and other users should be able to easily recognize without confusion terms and nomenclature relating to common visual aids which they use daily;

b) a visual aid definition that is closely related to action taken or expected as a result of encountering a specific visual aid affords little opportunity for confusion; and

c) the term "taxi-holding position" has migrated into information manuals produced by States intended for the education and use of pilots.

1.2.3.3 The working group concluded that there was obviously a need for different types of aids at holding positions at runway/taxiway intersections and at taxiway/taxiway intersections or holding positions established at locations other than taxiway/taxiway intersections. It was, therefore, felt that it might be appropriate to establish a terminology that makes a distinction between the two types of holding positions. As a result, it was proposed that the present generic term "taxi-holding position" should be replaced by the more specific terms "runway-holding position" and "intermediate holding position". However, some members of the working group had disagreed with this proposal and had considered that the current term was well established within the industry and among States. Since no real consensus could be reached, it had been agreed that the proposal be submitted for decision by the panel at the VAP/13 Meeting.

1.2.3.4 The issue was revisited by the meeting. In this context, the meeting was informed by the Secretariat that the term "taxi-holding position" was neither used in Annex 2 nor in Annex 6 and only to a very limited extent in the *Procedures for Air Navigation Services — Rules of the Air and Air Traffic Services* (PANS-RAC, Doc 4444), the *Procedures for Air Navigation Services — Aircraft Operations* (PANS-OPS, Doc 8168) and the *Manual of All-Weather Operations* (Doc 9365). Thus, the impact of the proposed change on ICAO documents other than Annex 14, Volume I would be minimal. Furthermore, the term was neither part of the air traffic control (ATC) phraseology nor was it used in the Aeronautical Information Publications (AIPs).

1.2.3.5 The meeting was also informed that in the United Kingdom the term "taxi-holding position" had been subdivided as follows:

a) "runway taxi-holding position" used to describe holding positions at runway/taxiway intersections; and

b) "intermediate taxi-holding position" used to describe holding positions at other than runway/taxiway intersections.

1.2.3.6 One member stated that the prefix "taxi" in the term "taxi-holding position" identified a holding position on the ground as opposed to one in the air. He also expressed concern that the proposed new term "runway-holding position" might indicate a holding position located on a runway.

1.2.3.7 Nonetheless, the meeting saw the advantages of the proposed change in terminology. In particular, the meeting considered that the use of the more specific terms "runway-holding position" and "intermediate holding position" would facilitate specification of the different visual aids required at the two types of holding positions. A show of hands indicated that a majority of the panel members (11:2) supported the proposal. Thus, the meeting endorsed the related proposal for amendment to Annex 14, Volume I with the following changes to the proposed definitions of the new terms:

Intermediate holding position. A designated position intended for traffic control at which taxiing aircraft and vehicles shall stop and hold, when so instructed by the aerodrome control tower, until further cleared to proceed.

Runway-holding position. A designated position intended to protect a runway, an obstacle limitation surface, a radio navigation sensitive/critical area or the area beyond a land and hold short position at which taxiing aircraft and vehicles shall stop and hold unless otherwise authorized by the aerodrome control tower.

1.2.3.8 One of the members opposing the proposed change in terminology pointed out that, in his opinion, it was not the responsibility of the VAP to define terms for aerodrome locations. He further opposed the related change of legend for the mandatory "B2 sign" to "runway-holding position".

1.2.4 **Lighting of holding positions established on taxiways at locations other than taxiway/taxiway intersections**

1.2.4.1 The working group had concluded that, at taxi-holding positions* established as per Annex 14, Volume I, paragraph 3.11.3, the Pattern A marking would be supplemented by stop bars and/or runway guard lights depending on the visibility and traffic conditions. Thus, it saw no need to extend the applicability of "taxiway intersection lights" to holding positions established as per paragraph 3.11.3. However, the working group had concluded that there might be a need to designate a specific holding position at locations other than taxiway/taxiway intersections, where there was no need for stop-and-go signals as provided by a stop bar. Accordingly, it had recommended that the use of "taxiway intersection lights" should also be applied at such holding positions.

1.2.4.2 The meeting endorsed this recommendation and, therefore, the proposal for amendment to Annex 14, Volume I referred to in section 1.2.3 above, expanded the application of "taxiway intersection lights" to include any intermediate holding position.

1.2.5 **Appropriateness of renaming "taxiway intersection lights" as "clearance bars"**

1.2.5.1 When commenting on the proposals for amendment to Annex 14, Volume I stemming from the VAP/12 recommendations, one State had opposed renaming "clearance bars" as "taxiway intersection lights". It was pointed out that, since it would be necessary to install such lights at locations other than taxiway/taxiway intersections, the proposed new name "taxiway-intersection lights" was not an appropriate one. In this context, the Secretariat brought to the attention of the Commission that possible further applications for this lighting system would need to be examined by the panel. Nonetheless, the Commission had agreed to endorse the suggestion of VAP/12 to rename "clearance bars" as "taxiway intersection lights" and the Second Edition of Annex 14, Volume I was amended accordingly. However, the Commission requested the Secretariat to examine with the assistance of the panel, if the use of taxiway intersection lights could be extended to other applications.

1.2.5.2 Since the meeting had concluded that there was the need for further application of "taxiway intersection lights" at intermediate holding positions, it was agreed that the more appropriate term for these lights would be "intermediate holding position lights" rather than "clearance bars".

1.2.6 **Apron marking**

1.2.6.1 In mid 1996, the working group was informed of an initiative of Airports Council International (ACI) and International Air Transport Association (IATA) to develop a joint *ACI/IATA Apron Markings and Signs Handbook*. The need to standardize, as far as possible, the markings and signs used on aircraft aprons at international airports had long been recognized by the two organizations. It was considered that standardization would improve recognition of such markings and signs and ultimately have the effect of increasing safety and reliability of aircraft movements and

* Proposed by the meeting to be renamed as "runway-holding position".

vehicle traffic on aprons. As a result, the working group agreed to await the outcome of ACI and IATA's work, before progressing its own work on reviewing the current ICAO Annex 14, Volume I specifications on apron markings and apron safety lines.

1.2.6.2 The meeting was apprised of the work carried out by ACI and IATA on the subject and the latest (third) draft of the *ACI/IATA Apron Markings and Signs Handbook* was distributed to the meeting. The meeting was advised that the proposed markings and signs included in the draft handbook were based on a study of "best practices" conducted by representatives of airport operators, airlines and other organizations. The handbook was intended for apron planners, all types of personnel working on aprons, pilots as well as air traffic and apron controllers.

1.2.6.3 The meeting reviewed in detail the various proposals contained in the draft handbook and concluded that:

a) it would be premature to consider the draft handbook as basis for the development of Standards or Recommended Practices for incorporation in Annex 14, Volume I at this point in time;

b) upon further development, the material contained in the draft handbook would provide excellent guidance material for inclusion in the *Aerodrome Design Manual*, Part 4 — *Visual Aids* (Doc 9157);

c) further development of the draft handbook by ACI/IATA should be co-ordinated with the ICAO Secretariat and the panel; and

d) pending completion of work on the ACI/IATA handbook, a further review of the current Annex 14, Volume I specifications on apron markings and safety lines would not be required.

1.2.6.4 The ACI representative appreciated the comments provided by the meeting on the draft handbook and looked forward to further co-operation with the panel through the Secretariat.

1.2.6.5 In light of the above, the meeting formulated Recommendation 1/6 in relation to the report on this agenda item.

1.2.7 Mandatory instruction marking

1.2.7.1 At the VAP/12 Meeting, the panel developed specifications on information markings. At that time, the panel did not see the requirement for mandatory instruction markings. However, when commenting on the VAP/12 amendment proposals, a few States had pointed out that a mandatory instruction marking could usefully supplement a mandatory instruction sign at certain situations e.g. a wide-throat taxiway. The Commission had agreed to this suggestion and had assigned the task of developing appropriate specifications to the VAP.

1.2.7.2 The working group had agreed that the colours used in the mandatory instruction marking should correspond to those already specified for a mandatory instruction sign *viz.* a white inscription on a red background. In this context, the appropriateness of pilots crossing a red marking was questioned. However, pilots within the working group had pointed out that a mandatory instruction marking was no different from a mandatory instruction sign which they routinely crossed when authorized to do so by ATC. The working group had also agreed that a mandatory instruction marking should be located on the left-hand side of the taxiway centre line and that the inscription should provide information identical to that of the mandatory instruction sign which it supplemented. It was further agreed that, where the taxiway surface was black e.g. an asphalt pavement, it would be beneficial for the red background of the marking to have an appropriate border. Accordingly, a proposal for amendment to Annex 14, Volume I had been developed incorporating specifications on mandatory instruction markings.

1.2.7.3 The meeting endorsed the above-mentioned amendment proposal. The meeting further agreed to extend the application of mandatory instruction markings to such locations where it would be impracticable to install a mandatory instruction sign in accordance with paragraph 5.4.2.1. It was also agreed that this application should be incorporated as a Standard.

1.2.8 **Improving the clarity of Annex 14, Volume I, paragraphs 5.3.15.1 to 5.3.15.3**

1.2.8.1 The working group had concluded that:

a) phrases like "low volume of traffic" etc. would be open to different interpretations;

b) terms related to traffic density should refer to a specific number of aircraft movements; and

c) a consistent use of a single classification of traffic density in Annex 14, Volume I would be preferable.

1.2.8.2 The working group had, therefore, recommended consistent use in Annex 14, Volumes I and II of the traffic density classification defined in the *Manual of Surface Movement Guidance and Control Systems (SMGCS)* (Doc 9476). Accordingly, the phrase "where there is a low volume of traffic" used in the subject three paragraphs should be revised to read "where the traffic density is low".

1.2.8.3 Furthermore, the working group had recommended that a definition of the term "traffic density" be included in Annex 14, Volume I, Chapter 1.

1.2.8.4 The meeting endorsed the recommendations of the working group. The meeting also agreed that a Note clarifying the term "movement" should be provided in conjunction with the definition of the term "traffic density".

1.2.9 **Visual aids for de/anti-icing pads**

1.2.9.1 The working group had noted that de/anti-icing pads were non-manoeuvring areas comparable to aprons. Accordingly, the working group had examined whether the present provisions in Annex 14, Volume I for marking and lighting of aprons and aircraft stands could be expanded to also include specifications for de/anti-icing pads. It had been agreed that, in principle, the concerned specifications could be applied and that there was no need to identify new visual aids for de/anti-icing pads.

1.2.9.2 The working group had also recommended that remote de-icing facilities located along an active taxiway should have taxiway intersection marking* to indicate the exit boundary of the facility and that in-pavement lights should be installed to further enhance night-time recognition of this marking. These lights should be located 0.6 m inward of the taxiway intersection marking and spaced every 6.0 m with the illuminated portion facing the de-icing pads. The working group had further recommended that the term "boundary lights" be used for these in-pavement lights. The photometric characteristics for boundary lights should be the same as those for intermediate holding position lights. Accordingly, a proposal for amendment of Annex 14, Volume I had been developed by the working group incorporating specifications on visual aids for de/anti-icing pads.

1.2.9.3 The meeting endorsed, in principle, the above-mentioned amendment proposal. The meeting, however, considered that the term "boundary lights" was too general in nature and agreed that the term "de/anti-icing pad exit lights" would be more suitable. The meeting also considered that, for clarity, an additional figure depicting a de/anti-icing pad located along an active taxiway provided with de/anti-icing pad exit lights should be incorporated into Annex 14, Volume I.

1.2.10 Visual aids for runway turn pads

1.2.10.1 In response to a request from the International Federation of Air Line Pilots' Associations (IFALPA), ICAO had agreed to develop specifications on runway turn pads. While many runway turn pads existed worldwide, there was no standardization for either the design or for the marking and lighting of such pads. The lack of standardization created problems for pilots utilizing runway turn pads.

1.2.10.2 It had been agreed that specifications on the physical characteristics of runway turn pads should be developed with the assistance of the Airport Design Study Group (ADSG) and that specifications on the marking and lighting should be developed with the assistance of the panel.

1.2.10.3 In reviewing current practices in States with regard to runway turn pads, the working group had concluded that:

a) pilots were concerned that very few States provided an indication of the point where a full turn must be commenced so that the aircraft will be properly aligned for take-off on the runway. The course reversal turn was critical for a number of large air carrier aircraft and becomes more critical as friction coefficients decrease;

b) States providing a full turn commencement indication utilized off-pavement alignment lights located well outside pavement boundaries. While off-pavement light indications might be satisfactory in good visibility, they were not satisfactory in conditions of poor visibility; and

c) off-pavement light indications require pilots to divert attention from the aircraft track and divide attention between the aircraft track and the indicator lights until a turn is commenced.

* Proposed by the meeting to be renamed as "intermediate holding position marking".

1.2.10.4 In light of the above, the working group had developed a proposal for visual aids for runway turn pads. The proposed aids included marking as well as taxiway centre line lights providing continuous guidance from the runway centre line through the runway turn pad to the point where a full turn was to be made. It had further been recommended that this point should be indicated by an array of three unidirectional turn bar lights spaced at 2 m and located perpendicular to the final segment of the marking. The turn bar lights should show green in the direction of the approach to the turn bar lights and their photometric characteristics should be identical to those of taxiway centre line lights. Finally, the working group had recommended that a definition of the term "runway turn pad" be included in Annex 14, Volume I, Chapter 1. For a pictorial representation of the runway turn pad marking and lighting as proposed by the working group, please refer to Figures 1-1 and 1-2 below.

1.2.10.5 The meeting reviewed the proposal developed by the working group and agreed, in principle, that specifications for runway turn pads should be introduced in Annex 14, Volume I. However, the meeting agreed that, in view of the low taxiing speed envisaged on the turn pad, the proposed spacing of the taxiway centre line lights providing continuous guidance from the runway centre line through the runway turn pad to the point, where a full turn was to be made, could be doubled without degrading safety. The meeting further agreed that the lighting aids should only be applicable in runway visual range conditions of 350 m or less.

1.2.10.6 Another issue that generated some discussion was the proposed distances between the taxiway centre line and the edge of the runway turn pad. However, it was clarified that, because of the critical nature of the manoeuvre associated with the runway turn pad, added margins were required compared to the clearance distances between the outer main wheel of the aircraft and the edge of a taxiway as specified by ICAO.

1.2.11 Visual aids for simultaneous intersecting runway operations

1.2.11.1 Draft regional provisions for the planning and implementation of simultaneous intersecting runway operations had been developed by the European Air Navigation Planning Group (EANPG) and submitted to States for comments on 17 March 1997. These provisions allowed for landings only on the secondary intersecting runway under restricted circumstances and in good visibility conditions. In this context, the meeting was advised that provisions for the planning and implementation of simultaneous intersecting runway operations on a worldwide basis were yet to be developed. The meeting was also advised that land and hold short operations had been conducted in several States for many years under less restricted circumstances compared to those proposed by EANPG. Furthermore, these operations comprised not only simultaneous intersecting runway operations but also land and hold short operations in connection with an intersecting taxiway or an approach/departure flight path.

1.2.11.2 The meeting noted that four terms existed to describe specific land and hold short operations. Those terms were simultaneous intersecting runway operations (SIRO), simultaneous operations on intersecting runways (SOIR), simultaneous operations (SIMOPS) and land and hold short operations (LAHSO). At least one of these terms, SOIR, was ambiguous, since this term was also used to indicate simultaneous operations on parallel or near-parallel instrument runways. The meeting also noted that the EANPG had proposed the use of the term "hold short procedures" for which no acronym yet existed.

1.2.11.3 The unanimous consensus of the panel members was that only a single term should be used to indicate any type of land and hold short operation, be it to hold short of another runway, an obstacle free area, a navigation critical/sensitive area or to hold short of any other aerodrome surface including, but not limited to, a taxiway or runway turn pad.

1.2.11.4 The consideration of utmost importance was that the term chosen for any land and hold short operation must be unambiguous and easily understood by both pilots and air traffic controllers. The meeting considered that only land and hold short operations met this criteria. The meeting also considered that the term "hold short procedures" was most ambiguous and could be easily confused and/or misunderstood by controllers and pilots.

1.2.11.5 In light of the above, the meeting agreed to use the term "land and hold short operation" for the purpose of this report.

1.2.11.6 The working group had approached this task by assessing currently specified visual aids to determine which aids could be used, with some modification if necessary, for land and hold short operations. The development of new aids had been considered, where a need could not be adequately satisfied by existing aids. Accordingly, the working group had evaluated the following visual aids:

a) **Visual approach slope indicator system**. To assist pilot in landing at the aiming point marking. An aircraft landing beyond this point has greater difficulty coming to a full stop prior to the intersecting runway. There was a unanimous support within the working group that a runway intended to be used for land and hold short operations shall be equipped with a visual approach slope indicator system.

b) **Land and hold short position marking**. A marking across the runway to indicate the location of the land and hold short position. There was a unanimous support within the working group that the land and hold short position marking should have the same characteristics as a taxi-holding position* marking, Pattern A, as shown in Annex 14, Volume I, Figure 5-6. The colour of the marking should be yellow.

c) **Mandatory instruction signs**. Existing Standards for mandatory instruction signs to supplement a Pattern A taxi-holding position, in Annex 14, Volume I, paragraph 5.4.2.3 are applicable. Signs are required on both sides of the runway abeam the taxi-holding position marking.

d) **Distance-to-go signs**. The working group saw no operational requirement for distance-to-go signs. Indeed, some practical difficulties were envisaged, since the distance-to-go would be different for land and hold short operations and for those operations using the full length of the runway. The working group agreed to develop guidance material on this subject for the benefit of States that might be interested in providing such signs. Such guidance material has not yet been developed.

e) **Land and hold short lights, flashing-white**. An array of minimum five unidirectional lights showing white in the direction of the approach to the land and hold short position. The lights should be installed perpendicular to the runway

* Proposed by the meeting to be renamed as "runway-holding position".

centre line at the hold short position and placed at intervals of 5 m. The middle light of the array should be on the runway centre line. All lights should flash simultaneously, at between 25 and 35 flashes per minute. Trials with this type of lighting had been conducted in one State. The lights were highly conspicuous and indicated the location of the hold short position but did not, in their own right, provide an instruction not to cross the hold short position. These lights were not turned on/off on a movement by movement basis and take-off and full length landing pilots ignored the lights and crossed them without specific ATC clearance. Since there was no requirement for authorization from the ATC to cross these lights, the majority of the working group members considered that this lighting system did not provide a sufficiently strong visual cue to protect the intersecting runway. Thus, they would not support the proposed lighting system.

f) **Land and hold short lights, fixed-red.** Existing standard runway end lights installed at the land and hold short position to indicate to pilots conducting land and hold short operations what is effectively the runway end. As there might be a need for aircraft to be cleared to cross the land and hold short position after stopping, these lights would need to be capable of being controlled by ATC in the same way as stop bars. The use of this type of lighting at the land and hold short position is fully consistent with existing stop bar operation except that there is no preferred failure mode. Since the hold short lights have to be seen while on final approach as well as during roll-out, existing taxiway stop bar lights do not have the appropriate photometric characteristics. Therefore, lights complying with Annex 14, Volume I, Appendix 2, Figure 2.9, Isocandela diagram for runway end light (red light) should be used.

Those members of the working group supporting the "flashing-white" configuration considered that insufficient account has been taken of the ATC human factor issues and workload aspects, emphasizing the danger of an incorrect selection/deselection of the "fixed-red" hold short lights. There was also significant concern that having to keep a constant mental note of the status of controlled lights would impact other ATC functions, especially separation and sequencing of aircraft.

The majority of the working group members supported making the provision of a controllable bar of fixed-red land and hold short lights a Standard, where it was intended to conduct land and hold short operations at night, and a Recommended Practice, where it was intended to conduct such operations by day only. The working group did not expect this type of operation to be conducted in conditions of low visibility.

g) **Land and hold short lights, flashing-red and supplementary elevated red.** For improved conspicuity, it was proposed that the red land and hold short lights flash in unison and/or that they be supplemented with a pair of elevated red lights at each end similar to the recommendation in Annex 14, Volume I, paragraph 5.3.17.5. Both fixed and flashing lights were considered for the elevated lights with flashing lights being preferred by one member because of their greater conspicuity.

There were no practical trials or evaluation data available to indicate that the fixed-red lighting system would not have sufficient conspicuity. The working group members were not inclined to support these variations to the basic fixed-red land and hold short lights until either aerodrome or simulator trials provided conclusive evidence that increasing the conspicuity was necessary.

h) **Taxi speed bar lights**. The lighting system, as described in paragraph 1.2.11.6 e) above, installed across the runway 300 m prior to the land and hold short position, indicating the point on the runway at which minimum taxi speed must be achieved after landing roll-out. This lighting system was not widely supported by the working group. The need to provide this additional visual cue was questioned. The additional cost as well as the contribution to increased visual clutter were noted. The working group felt that it would like to see some aerodrome or simulator trials clearly supporting the need for taxi speed bar lights before recommending their application.

i) **Extinguishing runway lights beyond the land and hold short position**. Subject to fixed-red lights being used to indicate the land and hold short position, the resemblance of a standard runway end lighting system would be enhanced, if all runway lights beyond the land and hold short position were extinguished when the hold short lights were illuminated. In this way, a pilot conducting a land and hold short operation would see the standard runway lighting presentation for the reduced length runway. Negative aspects of this proposal included:

1) the fluctuating view of the runway presented to approaching pilots, when there is a mixture of hold short and full-length operations;

2) a loss of visual cues to other pilots at the aerodrome including those operating on the intersecting runway and those taxiing;

3) in the event of an aircraft overrunning the land and hold short position, there would be a loss of visual cues to the pilot; and

4) increase in technical complexity in providing the necessary switching and control interlocks.

The working group did not envisage that land and hold short operations would be conducted in low visibility. It, therefore, considered that the loss of colour coding towards the runway end, *viz.* the yellow edge lights and red centre line lights, would be acceptable.

The working group did not consider that the proposal to extinguish the runway lights beyond the land and hold short position had sufficient merit to recommend its adoption. However, the working group considered that the option should be available, if a State so desired.

1.2.11.7 Based on the above evaluation, the working group had developed a proposal for amendment to Annex 14, Volume I incorporating specifications for visual aids for land and hold short operations including a visual approach slope indicator system, land and hold short position marking, mandatory instruction signs and controllable fixed-red land and hold short lights. In this context, it should be noted that this proposal did not take into account the trials suggested by the working group to evaluate flashing-red hold short lights, the addition of elevated lights to the red hold short lights and taxi speed bar lights. Should the results of such trials indicate the need for these facilities, it was recognized that additional amendments to the Annex would be required.

1.2.11.8 The subjects of the location of the hold short position and the determination of the reduced landing distance available were quite controversial. The working group had agreed that these issues should be resolved by specialists in aircraft operations and that the VAP task should be limited to developing the required visual aids to identify and give conspicuity to the hold short position.

1.2.11.9 The meeting was apprised of a flight simulator evaluation of the various proposals for land and hold short lighting aids recently performed in the United States. The simulation consisted of a total of five different lighting systems with twelve subject pilots participating. A formal report was not yet available. It was pointed out that the simulation only considered the lighting from the pilot's perspective and that it was equally important to consider the human factors and workload of ATC. It was, therefore, suggested that final conclusions regarding the need to control land and hold short lights could not be reached until the procedure had also been examined from the controller's perspective. The meeting was further apprised that demonstrations of land and hold short operations were presently conducted at several United States airports with the uncontrolled pulsing-white lighting system. Thereby, the controller's perspective with regard to *not* controlling the lights was under examination.

1.2.11.10 The simulation comprised the following land and hold short visual aids configurations:

Configuration 1: Holding position marking at the hold short position with a runway/runway intersection sign on both sides of the marking. No lighting system shown (Figure 1-3 below refers).

Configuration 2: 5 flashing-white lights located 0.6 m before the marking spaced at 5 m (Figure 1-4 below refers).

Configuration 3: 6 fixed-red lights located 0.6 m before the marking spaced at 6 m (Figure 1-5 below refers).

Configuration 4: 6 flashing-red lights located 0.6 m before the marking spaced at 6 m supplemented by 1 flashing elevated-red light on each side of the marking (Figure 1-6 below refers).

Configuration 5: 6 fixed-red lights located 0.6 m before the marking spaced at 6 m supplemented by 1 elevated fixed-red light on each side of the marking. In addition, a taxi speed bar consisting of 5 flashing-white lights spaced at 5 m was located 300 m before the red lights (Figure 1-7 below refers).

Configuration 6: 6 fixed-red lights located 0.6 m before the marking spaced at 6 m supplemented by 1 flashing elevated-red light on each side of the marking. In addition, a taxi speed bar consisting of 5 flashing-white lights spaced at 5 m was located 300 m before the red lights (Figure 1-8 below refers).

Note.— In addition to the lights, configurations 2 to 6 included the signs and markings, as described in configuration 1.

1.2.11.11 It should be noted that, in the simulation, the red lights appeared as bold as the white lights. It was considered that this would not be true for actual lights and that their adequacy should be verified through in-service testing.

1.2.11.12 For the various lighting configurations, the parameters for the evaluation included clearance to land (full length), normal hold short clearance, late hold short clearance, an announcement on the ATIS to expect a hold short clearance as well as the hold short clearance omitted. The evaluation also included one take-off scenario for each of the lighting configurations.

1.2.11.13 Based on the results of the simulator evaluation, the FAA as well as the IFALPA panel member, who participated in the evaluation, provided an overall rating of the various lighting configurations as follows:

	FAA	IFALPA panel member
Configuration 1	Extremely poor	Extremely poor
Configuration 2	Excellent	Extremely poor [1)]
Configuration 3	Good	Poor
Configuration 4	Poor	Poor
Configuration 5	Very good	Very good
Configuration 6	Very good	Excellent

1) The IFALPA panel member considered that lights operated regardless of clearance diminished the importance and meaning of the signal.

1.2.11.14 The pilots participating in the simulation indicated that any of the lighting systems were preferred rather than no lights being provided. The pilots further indicated that training was crucial to the success of any selected lighting system.

1.2.11.15 The meeting reviewed the results of the United States simulator evaluation as well as the overall rating of the various lighting systems provided by FAA and IFALPA and concluded the following:

a) a lighting system was needed to increase the conspicuity of the hold short position;

b) the lighting system should be applicable for a procedure based on mixed operations, *viz.* any combination of full length landings, hold short landings and departures;

c) the selected lighting system should be verified by in-service testing;

d) there was not a single "best" lighting configuration which had little or no flaws;

e) to ensure sufficient conspicuity the selected lighting system should include the flashing-white lights; and

f) the need to manually control land and hold short lights in order to provide a sufficiently strong visual cue to protect the intersecting runway had not been verified.

1.2.11.16 In light of the above conclusions, the meeting agreed that the land and hold short visual aid proposed by the working group were adequate except for the lighting system which was not considered to provide a sufficiently unique and bold indication of the hold short position. The meeting further agreed that, since the flashing-white lights had a proven performance record, they should be included in the selected lighting system.

1.2.11.17 The operation of the lighting system and the related human factors issues generated considerable discussion. One view was that the land and hold short lighting system would have to be controllable. As an aircraft might have to be cleared to cross the land and hold short position after stopping, it was considered that there was a need for a positive stop-and-go signal as provided by a stop bar. Another view was that, if the procedure was based on mixed operations on the secondary intersecting runway, the manual control of the lighting system would not be practicable. On the other hand, if the procedure consisted of hold short landings only with no mixing of operations, then the control of the lighting system might be feasible. In such a situation, ATC would, in effect, never have to change the status of the lights. The meeting could not reach a consensus on how to operate the lighting system.

1.2.11.18 Nonetheless, the meeting strongly felt that the current situation, where no international standards for visual aids for land and hold short operations were in place, was a potential hazard to the safety of such operations. The meeting, therefore, unanimously agreed to develop two different lighting configurations which provided the same quality in terms of conspicuity but allowed for the installation of a controlled or uncontrolled land and hold short lighting system. Except for the flashing-white lights, the proposed two lighting configurations consisted, in principle, of currently specified lights in Annex 14, Volume I. The two configurations were identified as follows:

Configuration A

a) Land and hold short position bar consisting of at least 6 unidirectional fixed-red lights (lights shall comply with Annex 14, Volume I, Appendix 2, Figure 2.9, Isocandela diagram for runway end light) located at right angle to the runway centre line and equally spaced at intervals not greater than 6 m supplemented by 1 elevated flashing-red light on each side of the land and hold short position; and

b) Land and hold short alert bar consisting of at least 6 unidirectional flashing-white lights located at right angle to the runway centre line and equally spaced at intervals not greater than 6 m at a distance of 300 m prior to the land and hold short position (lights shall be simultaneously illuminated between 25 and 35 cycles per minute).

Configuration B

a) Runway guard lights, Configuration A; and

b) Land and hold short alert bar consisting of at least 6 unidirectional flashing-white lights located at right angle to the runway centre line and equally spaced at intervals not greater than 6 m at a distance of 300 m prior to the land and hold short position (lights shall be simultaneously illuminated between 25 and 35 cycles per minute).

1.2.11.19 The meeting further developed a proposal for amendment to Annex 14, Volume I incorporating the agreed visual aids for land and hold short operations as follows:

a) visual approach slope indicator system (a Standard):

b) land and hold short marking: taxi-holding position* marking, Pattern A or Pattern B (a Standard);

c) land and hold short signs: taxi-holding position sign (a Standard); and

d) land and hold short lighting system: proposed Configuration A or B (a Standard).

1.2.11.20 Finally, the meeting formulated Recommendations 1/7 and 1/8 in relation to the report on this agenda item.

1.2.12 **Requirements for intersection take-offs**

1.2.12.1 The working group had agreed that at certain airports, depending on the layout of the runway/taxiway system, there could be a need to provide information on the take-off run available (TORA) for intersection take-off in order to avoid any possible pilot misunderstanding. It had also been recognized that any sign, if required, would be a confirmation on site of information already included in the aeronautical information publications. In addition, depending on State practices, ATC might state the TORA together with the take-off clearance.

1.2.12.2 Furthermore, the working group had concluded that there was no need to develop a new visual aid specifically for intersection take-offs. There was a consensus among the members, that the currently specified information signs in Annex 14, Volume I, could be expanded to include an intersection take-off sign to be used to disseminate the necessary information on the remaining TORA to the pilots. As regards the location, the working group recommended that an intersection take-off sign should be installed on the left side of the associated taxiway at a distance of at least 60 m from the centre line of the runway. Accordingly, the working group had developed a proposal for amendment to Annex 14, Volume I incorporating specifications for intersection take-off signs. For a pictorial representation of an intersection take-off sign, please refer to Figure 1-9 below.

1.2.12.3 The meeting reviewed and endorsed the above-mentioned amendment proposal developed by the working group.

* Proposed by the meeting to be renamed as "runway-holding position".

1.2.13 **Fibre-optic and variable message signs**

1.2.13.1 Over a period of five years, the progress of fibre-optic technology and its application on taxiing guidance signs had been examined by the working group. It had been assessed that:

a) fibre-optic signs had a higher luminance and hence a better performance than conventional signs in low visibility;

b) the luminance and legibility of this type of sign was angle-dependent. Values in excess of 50 per cent peak luminance were only available with viewing angles less than 20 degrees. There was some evidence to suggest that improved performance at angles in excess of 20 degrees would be achievable in the near future;

c) incorporating two colours in the sign, e.g. white and red, would require careful design of the sign to ensure that one colour is not masked by the other;

d) the legibility of individual characters was greatly affected by the number of light-emitting points used to form the character; and

e) the development of a fibre-optic sign in complete accordance with existing ICAO Standards providing total face illumination was currently impracticable due to prohibitive cost. In this context, potential problems with colour saturation were also anticipated.

1.2.13.2 Two different designs for fibre-optic signs had been developed as follows:

a) with fibre-optics as the sole source of illumination (the mandatory instruction carried by the red legend); and

b) with fibre-optics in addition to transillumination (white letters for the legend and the mandatory instruction carried by a red border).

1.2.13.3 The advantages of the first design were:

a) better mechanical resistance to jet blast and severe climatic hazards due to the absence of a plastic face; and

b) potentially less costly.

1.2.13.4 The advantages of the second design were:

a) dual mode, *viz.* the sign could be operated either as a conventional sign or as a fibre-optic sign;

b) exhibited closer compliance to present Standards when operated in the fibre-optic mode; and

c) by using white colours, the visual range of the sign was greater in equivalent conditions.

1.2.13.5 The convention of a mandatory sign formed by a red border with white legend appeared to have a better acceptance within the working group due to the closer compliance with the existing ICAO colour convention. The working group had also considered that, for improved conspicuity, a visible red border outlining the sign was of importance. A convention for information signs had not been developed.

1.2.13.6 Conventional signs have practical limits for achievable luminance on the sign face. Increase in sign luminance can only be achieved through the use of high energy levels. In addition, due to glare, the use of high luminance tends to reduce the legibility of the sign.

1.2.13.7 If information signs are to play a continuing pivotal role in surface movement, some improvement in the legibility of the signs in low visibilities may be necessary. Experiences so far suggest that some form of light-emitting point signs (e.g. fibre-optic/LED sign) would be the most reasonable option. This position is further validated by the experience with highway signs, particularly in Europe.

1.2.13.8 The enhanced conspicuity of fibre-optic signs used in low visibility conditions may be of a redundant value in consideration of the other visual aids required at a taxi-holding position. However, if such aids were not available, then signs using fibre-optic or similar technologies would be of greater importance.

1.2.13.9 The fact that the existing category I, II, III or joint II/III holding position sign is visible during all modes of operations indicates that there is a lack of flexibility in the current Standards. It could be considered that signs that convey a mandatory instruction should only be visible during the period when compliance is expected. Thus, a mandatory instruction sign, such as CAT III, should not have a message element except during low visibility operations. Furthermore, operational requirements, in particular those related to A-SMGCS, may require signs that convey a variable message.

1.2.13.10 The only reasonable method to comply with the present specifications today is to use an externally illuminated or a transilluminated sign. Either method will give a sign which is always visible in daytime conditions and when otherwise illuminated. In other words, current signs cannot be made easily switchable on or off in accordance with operational conditions.

1.2.13.11 In view of the above, the working group had seen the need for a variable message sign, i.e. a sign capable of presenting several pre-determined messages or no message, as applicable. The working group identified the following performance requirements for such a sign:

a) the sign should have a blank face when not in use. A pilot must not see an image or "ghost" of the message;

b) the sign should not present a message that could lead to an unsafe action from a pilot in case of failure;

c) short response time, i.e. the time required for the message to change; and

d) the message shall be created by light-emitting points only, by day as well as by night (different luminance levels will be required for day/night and in good/low visibilities);

1.2.13.12 There was concern within the working group that further developments of a standardized format for light-emitting point signs may be compromised, if the current sign specifications are not revised in such a manner to allow for an alternative format.

1.2.13.13 In light of the foregoing, the working group had reached the following conclusions:

a) existing sign specifications were sufficient in a great number of applications;

b) the increased visual range of signs using fibre-optic or similar technologies that provides for enhanced conspicuity in low visibility conditions was of value for taxiing guidance signs and particularly information signs;

c) existing specifications were written in a manner which might preclude the development of alternative illumination technologies and strategies;

d) currently it was not practicable to develop a fibre-optic sign that would be in strict accordance with the specifications. Some adjustment to the colour convention would be necessary; and

e) there was the need for a variable message sign, in particular in connection with A-SMGCS, and fibre-optic or similar technologies appear to provide the most practical means available today for the development of such a sign.

1.2.13.14 The meeting endorsed the above-mentioned conclusions of the working group. The meeting also endorsed the related proposal for amendment to Annex 14, Volume I introducing specifications for variable message signs.

1.2.13.15 The meeting was apprised of a further study undertaken in the United Kingdom to establish whether fibre-optic signs could be fully compliant with the conventional sign system in terms of letter and design size and colour coding. The legibility performance of such signs had also been evaluated. On the basis of the tests and trials carried out it had been concluded that:

a) existing signs adequately support the taxi operations currently being conducted at airports, but they may contribute to the reduction in taxi speeds used in low visibility conditions;

b) the fibre-optic technology can be added to transilluminated signs without significantly affecting the basic sign performance;

c) the best range performance is obtained by using white fibre-optics without a lit background. If the sign is also internally lit a significant percentage of the sign performance benefits available from the fibres is lost, but the range performance is still superior to the basic internally lit sign;

d) the use of red fibre-optics results in range performance that is inferior to that obtainable with white;

e) the field-of-view of the fibre-optics may present design problems in respect to the full range of viewing angles that are required for taxiway signs; and

f) character height and width, the number of fibres and rows making up a stroke all affect sign performance.

1.2.13.16 In light of the foregoing, the meeting recommended that:

a) the current sign specifications be examined for opportunities for amendment in such a way that the development of signs using new technologies will be facilitated;

b) Standards and Recommended Practices be developed for variable message signs for use in A-SMGCS based on studies, testing and operational trials taking into account new technology and human factors issues; and

c) the development programme be prioritized to ensure harmonization with other A-SMGCS projects.

1.2.13.17 The meeting further formulated Recommendation 1/9 in relation to the report on this agenda item.

1.2.14 **Runway distance remaining signs**

1.2.14.1 The runway distance remaining sign can be a very useful aid to assist assessment of take-off and landing performance particularly on the shorter runways found at regional airports. The sign also gives an indication of take-off-run available to aircraft which are making an intersection take-off and assistance to the landing aircraft in locating an exit taxiway. There is a significant body of airline opinion which would like to see this sign in use at certain aerodromes, where its presence is considered desirable to enhance safety.

1.2.14.2 Currently, there is no provision for a runway distance remaining sign in Annex 14, Volume I. Furthermore, where the sign is in use at international aerodromes, it is non-compliant with the Standard in Annex 14, Volume I, paragraph 5.4.3.34 which states that "the use of numbers alone on the manoeuvring area shall be reserved for the designation of runways".

1.2.14.3 In view of the above, the working group had agreed to develop specifications for runway distance remaining signs.

1.2.14.4 The working group recognized that the sign, which had been in use for many years in several States at aerodromes which declared distances in feet, was well proven. This sign, located at 1 000 foot intervals along the left side of the runway, consisted of a white numeral on a black background. However, since the sign was considered a location sign, the working group had agreed that a proposed metric sign should conform to present ICAO Standards for colours of signs.

1.2.14.5 The main problem the working group had to address was how to adapt the current sign for use at aerodromes which declared distances in metres. The metric sign needed to be of similar size and clearly indicate, at a glance, what units are being displayed. The working group considered that this would be achieved by displaying the distance remaining in kilometres where the mandatory presence of the decimal point would indicate the metric units. For example, a typical runway of 6 000 ft, or 1 829 m, in length would display:

either	5	4	3	2	1	(thousands of feet)
or	1.5	1.2	0.9	0.6	0.3	(kilometres)

1.2.14.6 The meeting endorsed, in principle, the proposal developed by the working group. However, the meeting saw the need to specify two types of signs, *viz.* Type A for use in States where the metric system was applied and Type B for use in States where the imperial system was applied. The colours of the proposed sign also generated some discussion. The meeting recognized that existing military specifications called for a sign consisting of white numerals on a black background. It would, therefore, appear appropriate to use the same colours for the proposed ICAO sign. It was not considered necessary to strictly apply the ICAO colour convention for location signs. In this context, it was pointed out that the use of white on black would facilitate the use of LED technology for such signs, which could prove advantageous for specific applications where a variable message sign would be required, e.g. distance remaining signs on a land and hold short runway.

1.3 EXISTING VISUAL AIDS TO BE MODIFIED TO FACILITATE INTRODUCTION OF A-SMGCS

1.3.1 The meeting reviewed and refined the amendment proposals related to existing visual aids to be modified to facilitate the introduction of A-SMGCS and the results are reflected in Appendix D to the report on this agenda item. The meeting also reviewed and refined the associated guidance material proposed for inclusion in the *Aerodrome Design Manual*, Part 4 and the results are reflected in Appendix F to the report on this agenda item. The following paragraphs detail the more significant issues discussed and conclusions reached.

1.3.2 Review of A-SMGCS developments

1.3.2.1 Early in the work programme the working group had become aware that, whilst a considerable amount of development activity was in hand related to specific technology enhancements, there were very few systems studies or tests of the type that would bring together all aspects of A-SMGCS, i.e. operational, technical and regulatory aspects. Most technology developments were specifically focused on the short-term enhancement of tools used by air traffic controllers, e.g. surface movement radar.

1.3.2.2 Since visual aids requirements usually result from operational considerations and are primarily used by pilots, the working group was not initially able to identify many requirements for new airport visual aids. However, the experts on the panel began work to identify improvements to existing visual aids that in their judgement would be required in the future. The results of this work is reported below.

1.3.2.3 At the present time, there is a clearly identifiable increase in the amount of research and development being applied to the overall subject of A-SMGCS. Unfortunately, this impetus had occurred too late to be of real assistance to the panel.

1.3.2.4 Technology demonstrations in Europe and the United States are now increasingly being integrated into total system studies which are beginning to address the complete range of issues. One recent significant advance is the finalization of ICAO operational requirements (OR) for A-SMGCS by the All Weather Operations Panel (AWOP).

1.3.2.5 The A-SMGCS operational requirements defines four primary functions of an A-SMGCS, *viz.* surveillance, routing, guidance and control.

1.3.2.6 **Surveillance** requires the provision of suitable sensors. Surface movement radar, in-pavement sensors, multi-lateration, mini-radar networks and global navigation satellite system (GNSS) are typical of the technology being evaluated. In some demonstrator programmes, data from various combinations of these sensors are fused to provide high integrity position information on all aircraft and operational vehicles within the A-SMGCS area. Future research will determine whether this surveillance data will only be used for monitoring purposes or whether it will be used as the basis for some form of guidance signal. If the latter course of development is pursued, the required positional information would probably have to be more accurate to ensure that the ICAO separation requirements can be met. However, the panel can reasonably conclude that no ground visual aids will be required to support the surveillance function.

1.3.2.7 **Routing** is a function that in the future is expected to be provided as an output from the air traffic management system. This management system will use computer-aided systems to enable ATC to manage the complete aircraft movement from the gate at the departure airport to the gate at the arrival airport. It is envisaged that a route validated by ATC will be issued for each ground movement, taking account of such issues as arrival and departure sequencing, taxi times, fuel burn economy, tactical and strategic planning, separation Standards and conflict avoidance. The pilot or vehicle driver is expected to receive the routing information by some means of data link. Some form of cockpit display may be an element of such a system. It is not envisaged at present that any ground visual aid will be required for the routing function. However, it is possible that future research may show that the use of variable message signs, for example at the departure gate may have a role in reducing the requirements for voice or data link capacity. Furthermore, as will be seen in later paragraphs, visual aids to be provided for guidance and control may inherently provide an indication of the route to be followed.

1.3.2.8 **Guidance** is the function that enables the pilot or driver to accurately follow the assigned route. Visual aids currently in Annex 14, Volume I already address this function. Paint markings and taxiway centre line lights do enable pilots to follow the centre line of taxiways and stands within very close limits (better than $\pm$ 1 m) thereby meeting the ICAO design requirements for aircraft separation. Taxiway signage necessarily augments the centre line cues enabling the pilot to fix the position of the aircraft at specific points on the taxiway system. In all the current A-SMGCS developments and demonstrations, there is no system other than visual aids available to provide the required highly accurate lateral guidance. In relation to the guidance function of A-SMGCS two areas of development are identifiable. Firstly, the characteristics of existing aids need to be enhanced to ensure that their operational performances match the future requirements imposed by the sustaining of high movement rates in nearly all weather conditions (down to 75 m RVR). Secondly, the sophistication and integrity of the taxiway lighting system will need to be improved to permit the full exploitation of selective route designation.

1.3.2.9 **Control** is the function where the most significant changes may be anticipated. It is becoming clear that, if A-SMGCS developments are to produce improvements in efficiency whilst providing acceptable safety levels, institutional issues related to the attribution of responsibilities within modified procedures will have to be addressed. Depending on the outcome of such considerations, it can be expected that there will be a need for new visual aids.

1.3.2.10 Since pilots insist that they must at all times have full situational awareness and be in control of their aircraft, it seems inevitable that much, if not all, of the additional control information that will be required by A-SMGCS will be displayed through the medium of ground visual aids. Cockpit displays and modified crew procedures will have an important role, but it seems likely that visual aids will be identified as the best means of passing control information to pilots and drivers.

1.3.2.11 The switching of small segments of taxiway lighting together with the use of stop bars, is one means of control that is currently under evaluation in various projects. Careful selection of switching strategies taking full account of human factor issues may enable aircraft movements to be controlled in terms of position and taxi speed. Selectable rapid exit taxiway lighting is one possible means of designating the runway exit to be used and can, with appropriate procedures, contribute to the reduction of runway occupancy and hence taxi times. Another candidate for the control function, offering the possibility of easy-to-read unambiguous messages that can provide pilots with clearances, instructions and situational awareness information, is the variable message sign.

1.3.2.12 In order for effective Standards and Recommended Practices (SARPs) to be developed for variable message signs and other new visual aids, the working group considered that it was important that the panel continue to monitor and approve all new proposals.

1.3.2.13 A-SMGCS is likely to develop significantly over the next three years. In some research programmes the emphasis is on safety (runway incursion prevention), in others the primary goal is efficiency. Bearing in mind the expected future increase in airport movements and the evidence already available that, at some airports, the inadequate performance of the ground movement system is already adversely affecting the arrival rate, particularly in low visibility conditions, the development of A-SMGCS will continue. There are, at present, diverging views on the degree to which future taxiing movements will be autonomous. At one extreme, the view is held that adequate airport and on-aircraft facilities will be provided for the pilot to self-navigate from stand to departure with minimal ATC intervention. At the other extreme, an increasing measure of mandatory control by ATC is anticipated.

1.3.2.14 Overall, it could be stated that, in the period leading up to the VAP/13 Meeting, there had been little evidence of well-identified new visual aids requirements. However, with the availability of the ICAO operational requirements and the increasing pace of research in a number of countries, it can be predicted that there will shortly be a need for additional SARPs to be developed by ICAO for new visual aids for A-SMGCS.

1.3.3 Improving the conspicuity of markings through the use of reflective material

1.3.3.1 Recent advances in material production and application methods had resulted in significant cost benefit improvements in the use of reflective materials and recent tests at airports in the United States had shown that there are significant advantages to be had in their use. In the last 15 years, at least two major evaluations had been undertaken by the United States on the use of reflective materials for airport pavement markings. The first evaluation was conducted in the period 1981-1982 and had the following objectives:

a) to determine whether reflective markers could enhance night-time visual guidance and reduce minimums for category I and non-precision approaches; and

b) to determine if reflective markings could improve the safety of operations particularly in wet runway conditions.

1.3.3.2 Flight tests were conducted at two airports and concluded that visual contact height was not enhanced prior to reaching decision height/minimum descent altitude (DH/MDA) by the use of reflective pavement marking. However, the test programme demonstrated that, in the opinion of a widely diversified sample of user pilots, the reflective markings were effective in improving the safety of operation on take-off, final approach, flare, touchdown, landing and roll-out. Under rainy, wet night-time conditions, the pavement markings were significantly enhanced by the use of reflective material.

1.3.3.3 The second major evaluation was conducted in 1993-1994 and compared two types of glass beads (the Type I made from scrap glass and currently used in road markings and the more expensive Type III, specifically manufactured glass spheres with a higher refractive index) embedded in a variety of marking materials and applied as test strips at three airports chosen for their climatic variation. This study was aimed at determining what operational benefits could be gained in using reflective glass beads in aerodrome pavement marking materials. Over the evaluation period, a series of flight and ground tests were conducted aimed at assessing the reflectivity, durability and friction qualities of the test markings, when compared to non-beaded markings. These tests showed that:

a) the use of reflective glass beads greatly enhanced the conspicuity of markings on all aerodrome surfaces;

b) the cheaper Type I material is as effective as the more expensive Type III;

c) the use of glass beads in markings improves the friction qualities of the marking when compared with non-beaded markings;

d) the use of glass beads in markings minimizes rubber adherence and improves durability when compared with non-beaded materials; and

e) the use of glass beads in aerodrome markings increases the overall cost of marking typically by some 50 per cent but the improved durability results in less frequent "re-painting".

1.3.3.4 In light of the foregoing, the working group concluded that there was now sufficient evidence of improved conspicuity of pavement markings by the use of reflective materials and recommended that their use should become a Recommended Practice.

1.3.3.5 The meeting fully endorsed the conclusion of the working group. The meeting also endorsed the related amendment proposals to Annex 14, Volume I and the *Aerodrome Design Manual*, Part 4.

1.3.4 Taxi-holding position* marking

1.3.4.1 The working group had examined the adequacy of the dimensions specified in Annex 14, Volume I for taxi-holding position markings (*viz.* Patterns A and B in Annex 14, Volume I, Figure 5-6). The discussions revealed a division of opinion. One view was that the dimensions specified in Annex 14, Volume I had been proven, by experience, to be adequate and that there was no need to increase them. Another view was that the dimensions specified were inadequate particularly where the marking would be viewed at lower angles from vehicles or the cockpits of smaller aeroplanes in conditions of low visibility. No consensus could be reached and it had been agreed that a proposal including increased dimensions of the marking should be developed and submitted for review by VAP/13.

1.3.4.2 The meeting agreed that the enhancement of existing visual aids would be a simple and effective way to increase airport capacity. Accordingly, the meeting supported the proposal for amendment of Annex 14, Volume I as presented.

1.3.5 Light intensities for taxiway centre line lights and stop bars

1.3.5.1 The need for taxiway centre line lights and stop bars with higher than currently specified intensities had been identified by the working group for specific applications where greater conspicuity would be required. In particular, these applications included taxiway centre line lights and stop bars on taxiways and aprons managed by an A-SMGCS as well as stop bars requiring a wide beam fixture. Accordingly, the working group had initiated a desk (computer) study with the objective of developing more demanding isocandela diagrams for such applications for incorporation in Annex 14, Volume I. The study had not been supported by simulation or in-field trials.

1.3.5.2 The following operational requirements had been applied to develop the photometric characteristics:

a) taxiway centre line lights and stop bars to provide the necessary visual cues for guidance, routing and control in visibilities down to an RVR of approximately 75 m with background luminance ranging from night to bright foggy day conditions; and

b) stop bar lights to become visible at a distance from the stop bar that will:

   1) enable the aircraft to come to a full stop while allowing the pilot to keep the lights in sight; and

   2) permit a comfortable deceleration of the aircraft below the maximum value authorized by the aircraft manufacturer.

1.3.5.3 The following assumptions had been applied in the study:

a) **Atmospheric behaviour**: Allard's law is valid to describe light transmission within the atmosphere;

* Proposed by the meeting to be renamed as "runway-holding position".

b) **Human eye behaviour**: The eye's illuminance threshold, E_{th}, is a function of the background luminance, L_B;

c) **Evaluation of RVR**: At low visibilities, the RVR is calculated by means of Allard's law and is related to a "luminous intensity of reference"; and

d) **Guidance by means of taxiway centre line lights**: A visual segment of three consecutive lights at ICAO current spacing is needed to provide guidance to pilots both on straight and curved sections. The visual segment in terms of number of lights should not decrease as the aircraft proceeds.

Note.— In an A-SMGCS, taxiway centre line lights are intended to provide routing and control by means of selective switching.

1.3.5.4 The results of the study were presented in the form of isocandela diagrams showing required light intensities.

1.3.5.5 Furthermore, the working group had concluded that it was technically feasible, using state-of-the-art technology, to produce light fixtures meeting the required light intensities resulting from the study. A prototype lamp, equipped with green dichroic filter and a 100 W lamp, had been developed in Belgium. The photometric characteristics of this prototype lamp exceeded the required light intensities at every significant point (i.e. at vertical angles between 7° and 10° as well as at horizontal angles between -10° and +10°).

1.3.5.6 The results of the study generated considerable discussion. One member strongly opposed the proposal to incorporate more demanding isocandela diagram for taxiway centre line lights and stop bars in Annex 14, Volume I. He pointed out that existing light intensities were adequate for use in runway visual range conditions down to a value of 75 m. The meeting fully agreed that the use of currently specified intensities for taxiway centre line lights did not pose a safety problem. However, taxiing speed would have to be considerably decreased in low visibility conditions which would adversely affect airport capacity. It was further clarified that the concept of using centre line lights in an A-SMGCS differed significantly from that of the conventional use of such lights. An A-SMGCS should be capable of operating at its design capacity in visibility conditions down to the selected aerodrome visibility operational level (AVOL). Delays in ground movements should be reduced and growth in operations should be accommodated without increase in delays on the ground. This could only be accomplished by maintaining ground movements at a certain pre-determined speed. The use of taxiway centre line lights of higher intensity was considered to effectively contribute to this objective by the provision of enhanced visual cues.

1.3.5.7 In light of the foregoing, the meeting endorsed, in principle, the proposal to incorporate the new isocandela diagrams for taxiway centre line lights and stop bars in Annex 14, Volume I. However, it was pointed out that these diagrams were only applicable where such lights were included in an A-SMGCS and where, from an operational point of view, higher intensities were required to maintain ground movements at a certain speed in low visibilities or in bright daytime conditions. Accordingly, the meeting revised the proposal for amendment to Annex 14, Volume I developed by the working group.

1.3.5.8 The meeting further agreed to upgrade Annex 14, Volume I, paragraph 5.3.17.11 specifying light intensities for stop bars to a Standard.

1.3.5.9 One member strongly opposed the reference to "automatic" control of stop bars included in the detailed amendment proposal. He pointed out that stop bars should always be manually controlled by ATC. This view was not, however, shared by the majority. They felt that, in connection with an A-SMGCS, automatic control of stop bars might become feasible in the future.

1.3.6 **Elevated and in-pavement runway guard lights**

1.3.6.1 In the First Edition of Annex 14, Volume I (July 1990), taxi-holding position* lights were recommended for installation at taxi-holding positions intended for use in RVR conditions less than a value of 800 m and at other taxi-holding positions where enhanced conspicuity was needed. Taxi-holding position lights consisted of elevated fixtures and were located at each side of the taxi-holding position. Initially, an isocandela diagram was not included in the Annex. Instead, it was recommended that the intensity of the light should be adequate for the given visibility and ambient light conditions.

1.3.6.2 The VAP/12 Meeting brought several changes to the taxi-holding position lights. They were renamed as "runway guard lights" to emphasize their purpose. A new configuration of the runway guard lights, consisting of a row of in-pavement light fixtures, was added (as Configuration B) to provide an alternative for pavement configurations (e.g. wide-throat taxiways) which were not well-addressed by the elevated lights. The application of elevated runway guard lights was changed to a Standard, so that such lights are now installed where a stop bar is not provided and the associated runway is used in conditions less than 550 m RVR or in conditions less than 1 200 m RVR where the traffic density is high. Finally, isocandela diagrams were included for elevated (Configuration A) and in-pavement (Configuration B) runway guard lights.

1.3.6.3 As the number of operations continues to increase at many airports around the world, the opportunity for runway incursions also increases. Runway guard lights are an effective way of increasing the conspicuity of the location of taxi-holding positions in visibility conditions above as well as below 1 200 m RVR. As a result, a need has arisen to provide for a runway guard light fixture which is intended for use during the day with "good" visibility.

1.3.6.4 An evaluation of elevated runway guard light intensities had been conducted in the United States, the results of which were reviewed by the working group. The primary objective was to improve existing elevated runway guard lights so that they are conspicuous in all visibilities, during day and night. Two types of fixtures had been evaluated:

a) those designed to be powered from a 120V AC, 60 Hz, circuit; and

b) those designed to be powered from a 6.6A series circuit.

1.3.6.5 The results were summarized as follows. The constant voltage fixture produced a peak light intensity along the centre axis of about 940 cd. The constant current fixture with lamps of a similar wattage rating (about 115 W) produced a peak intensity of about 4 000 cd. Both fixtures were adequate for daytime use during good visibility conditions. However, when viewed during the day in visibility conditions of about 183 m RVR, both fixtures were visible but not eye-catching at a distance of 150 m. The constant current fixture was eye-catching at a distance of 120 m, while the constant

* Proposed by the meeting to be renamed as "runway-holding position."

voltage fixture did not become eye-catching until a distance of 60 m was reached. During good visibility, the use of a visor over each lamp produced significantly better contrast by shielding sunlight from each lamp. The contrast was further increased by colouring the front face of the fixture black. The optimum flash rate was found to be 48 flashes per minute (FPM) per lamp. In order to provide a tolerance, a range of 45-50 flashes per minute per lamp was recommended.

1.3.6.6 Using the results from the aforementioned evaluation, the RTCA, Inc. Special Committee 184 (SC-184) had developed minimum performance and installation standards for runway guard lights. An isocandela diagram was developed in accordance with the isocandela curves defined in the Second Edition of Annex 14, Volume I (July 1995). However, the intensity within the main beam for each lamp had been defined as a minimum average intensity of 3 000 cd while steady-burning. It was defined in this manner as a result of the flash duration being outside the range over which the formula for determining effective intensity was valid.

1.3.6.7 Although in-pavement runway guard light fixtures were not included in the aforementioned evaluation, the members of RTCA SC-184 and other representatives from the aviation industry in the United States witnessed various candidates for in-pavement runway guard light fixtures at the FAA William J. Hughes Technical Center. Since, for typical pavement configurations, taxi-holding positions were often approached from acute angles, it was determined that a wide-beam fixture was necessary. Thus, RTCA SC-184 developed an isocandela diagram with a horizontal main beam of ± 24 degrees and a minimum average intensity of 1 000 cd. Once again, the defined intensity was for a steady-burning light. In addition to the reasons mentioned for the elevated runway guard light, it was envisaged that the in-pavement runway guard light fixtures were distinct from the flasher mechanism. Therefore, specifying the intensity was significantly easier by developing an isocandela curve based on a steady-burning light. The Technical Center and SC-184 also found that a flash rate of 30 - 32 flashes/minute per fixture was ideal for fixtures with lamps rated at 6.6A. For daytime use, it was especially important that the flash rate should be slow enough (or the lamp rise time fast enough), so that the peak light output during the flash period reached or almost reached the steady-burning intensity for that lamp.

1.3.6.8 The working group had been kept abreast of the research as it continued and had agreed that, based thereon, a proposal for revised intensities for runway guard lights intended for use during the day should be developed and submitted for review by the VAP/13 Meeting. It had further been suggested that such a daytime intensity might also be appropriate for runway guard lights where specified as components of an A-SMGCS.

1.3.6.9 The meeting reviewed and endorsed the proposal for higher intensities for runway guard lights intended for use during the day. The meeting further endorsed the use of such intensities for runway guard lights where specified as components of an A-SMGCS and where, from an operational point of view, higher intensities were required to maintain ground movements at a certain speed.

1.4 NEW VISUAL AIDS FOR A-SMGCS

1.4.1 The meeting reviewed and refined the amendment proposal related to new visual aids for A-SMGCS and the results are reflected in Appendix E to the report on this agenda item. The following paragraphs detail the more significant issues discussed and conclusions reached.

1.4.2 Rapid exit taxiway indicator marking and lighting

1.4.2.1 During the recent years, it has become evident that existing airport capacity must be maximized, if present and future growth in air traffic is to be contained. One of the factors, which influences airport capacity, is the runway capacity or hourly movement rate. Runway occupancy time by individual aircraft, if longer than necessary, has the effect of reducing runway capacity. In order to reduce runway occupancy time during the landing phase, the need was identified to enhance the conspicuity of the approach to a rapid exit taxiway not only in low visibility but particularly in good conditions during day and night.

1.4.2.2 It was agreed that the visual aids to enhance the conspicuity of the approach to rapid exit taxiways had to be simple and self-evident. The markings on the runway proposed by United Kingdom were angled stripes, ///, //, /, which counted down the distance remaining to the rapid exit taxiway. These markings were located at 100 m longitudinal spacing with the final marking located 100 m from the point of tangency between the runway centre line and the yellow rapid exit taxiway centre line. The markings were located on the same side of the runway centre line as the associated rapid exit taxiway and were slanted to prevent misinterpretation by aircraft landing in the reciprocal direction.

1.4.2.3 The aim was to enable pilots to decelerate their aircraft after touchdown to a platform speed of, for example, 60 knots, which should be maintained until the approach to the next suitable rapid exit taxiway. At this point, further deceleration to turn-off taxi speed should be made. This procedure, compared with the usual practice of continuous deceleration to taxi speed, would reduce runway occupancy time without jeopardizing safety.

1.4.2.4 A trial was conducted in a B747 simulator in the United Kingdom during February 1996, in which airline pilots from both United Kingdom and United States participated. Primarily, the trial evaluated the benefits of a lighting pattern to assist the use of rapid exit taxiways. The results showed that there was a potential method of reducing runway occupancy times by using lights to enhance the markings. The lights used in the trial were called rapid exit taxiway indicator lights (RETILs) and yellow was the favoured colour. The lights were located at the approach end of each marking. Thus, the 3, 2, 1 indication was preserved. The RETILs were clearly identified as a useful aid for maintaining higher speeds on the runway. The preferred lateral spacing of the lights was 2 m.

1.4.2.5 In March 1997, RETILs were installed at London Gatwick Airport and rapid exit taxiway indicator markings were provided to match. Runway centre line light fixtures were used. Since it was considered advantageous to have the RETILs illuminated even when the runway lights were switched off during daytime, the fixtures were connected to an independent circuit. For a pictorial representation of the proposed rapid exit taxiway indicator markings and lights, please refer to Figure 1-10 below.

1.4.2.6 The meeting was apprised of the experiences from the installation of RETILs at Gatwick which, so far, had proven to be very promising. Reduced aircraft runway occupancy times of 3 to 5 seconds had been measured and it was expected that, when pilots had become more familiar with the new aids, further improvement in reduced runway occupance times would be experienced. The objective at Gatwick was to increase the hourly capacity of the runway by one movement. If such an increase could be achieved, the installation of RETILs would become a cost-effective investment.

1.4.2.7 The meeting agreed that specifications on rapid exit taxiway indicator marking and lighting should be incorporated into Annex 14, Volume I as a Recommended Practice. The meeting further agreed that, where provided, the marking should always be supplemented by the lighting system, i.e. the marking should not be provided alone. As regards light intensities, the meeting recommended that the appropriate isocandela diagram for runway centre line lights should apply.

1.5 CONCLUSIONS

1.5.1 The meeting agreed that it had nearly accomplished the assigned tasks under work programme Item 2 — Visual aids for SMGC. On the other hand, the meeting recognized that a significant amount of work remained to be done under work programme Item 6 — Visual aids for A-SMGCS, in particular related to the development of new visual aids for advanced surface movement guidance and control systems.

1.5.2 In light of the foregoing, the meeting formulated the following recommendations:

RSPP **Recommendation 1/1 — Amendment to Annex 14, Volume I — Visual aids for SMGC**

That Annex 14, Volume I be amended as indicated in Appendix A to the report on this agenda item.

RSPP **Recommendation 1/2 — Amendment to PANS-RAC**

That PANS-RAC be amended as indicated in Appendix B to the report on this agenda item.

RSPP **Recommendation 1/3 — Amendment to PANS-OPS, Volume II**

That PANS-OPS, Volume II be amended as indicated in Appendix C to the report on this agenda item.

RSPP **Recommendation 1/4 — Amendment to Annex 14, Volume I — Visual aids for A-SMGCS**

That Annex 14, Volume I be amended as indicated in Appendices D and E to the report on this agenda item.

Recommendation 1/5 — Amendment to the *Aerodrome Design Manual*, Part 4 — *Visual Aids*

That the *Aerodrome Design Manual*, Part 4 be amended as indicated in Appendix F to the report on this agenda item.

Recommendation 1/6 — *ACI/IATA Apron Markings and Signs Handbook*

That a proposal for amendment of the *Aerodrome Design Manual*, Part 4 related to apron marking and apron safety lines be developed by the Secretariat in close co-operation with ACI and IATA based on the *ACI/IATA Apron Markings and Signs Handbook* (paragraph 6.5.1 refers).

Recommendation 1/7 — Land and hold short operations

That the term "land and hold short operations" be adopted for any type of land and hold short operation, be it to hold short of another runway, an obstacle free area, a navigation critical/sensitive area or to hold short of any other aerodrome surface including, but not limited to, a taxiway or runway turn pad.

Recommendation 1/8 — Operational requirements for land and hold short operations

That operational requirements for the planning and implementation of land and hold short operations for worldwide application be developed by ICAO with a certain degree of urgency.

Recommendation 1/9 — Variable message signs

That Standards and Recommended Practices for variable message signs for use in A-SMGCS be developed with the assistance of the Visual Aids Panel (paragraph 6.5.1 refers).

Recommendation 1/10 — Visual aids for A-SMGCS

That the task of further development of visual aids for A-SMGCS be accomplished with the assistance of the Visual Aids Panel (paragraph 6.5.1 refers).

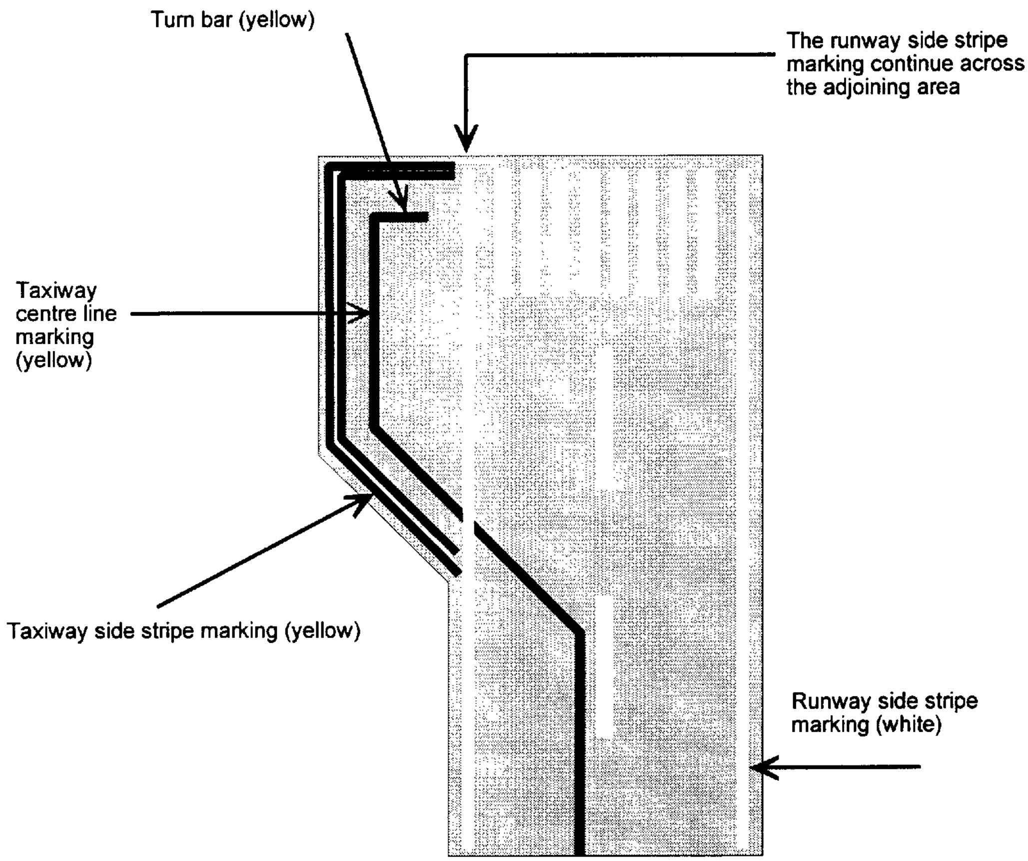

Figure 1-1. Runway turn pad markings as proposed by the working group (not to scale)

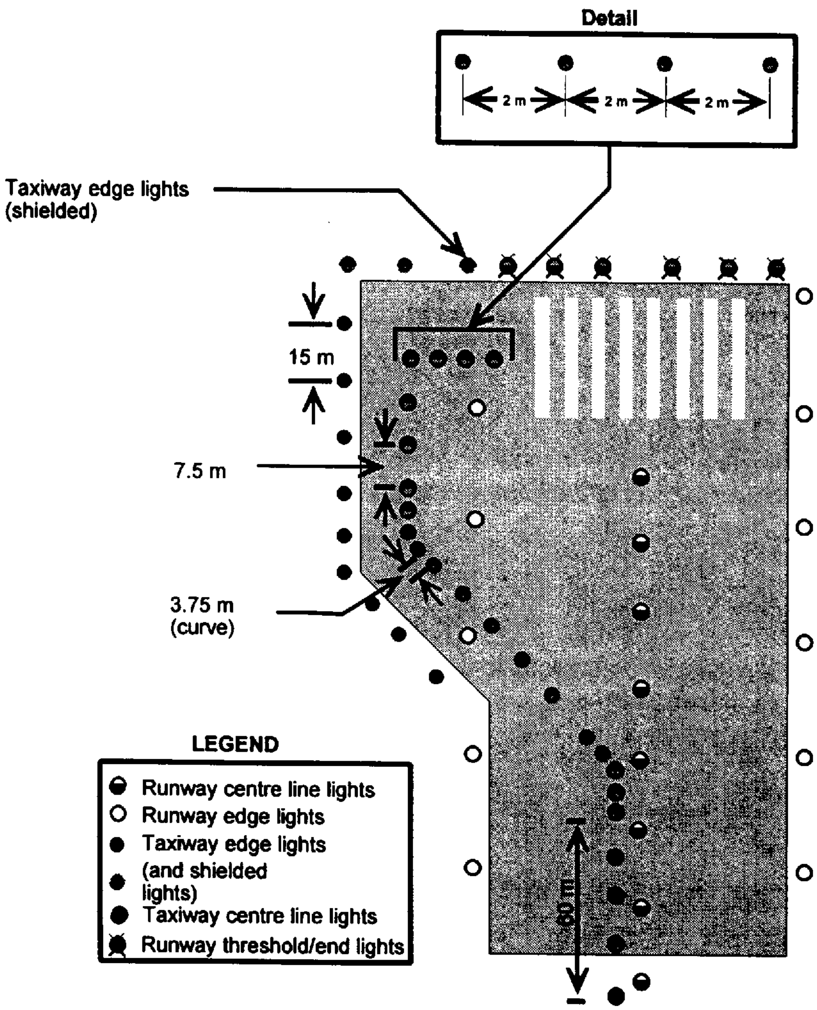

Figure 1-2. Runway turn pad lights as proposed by the working group (not to scale)

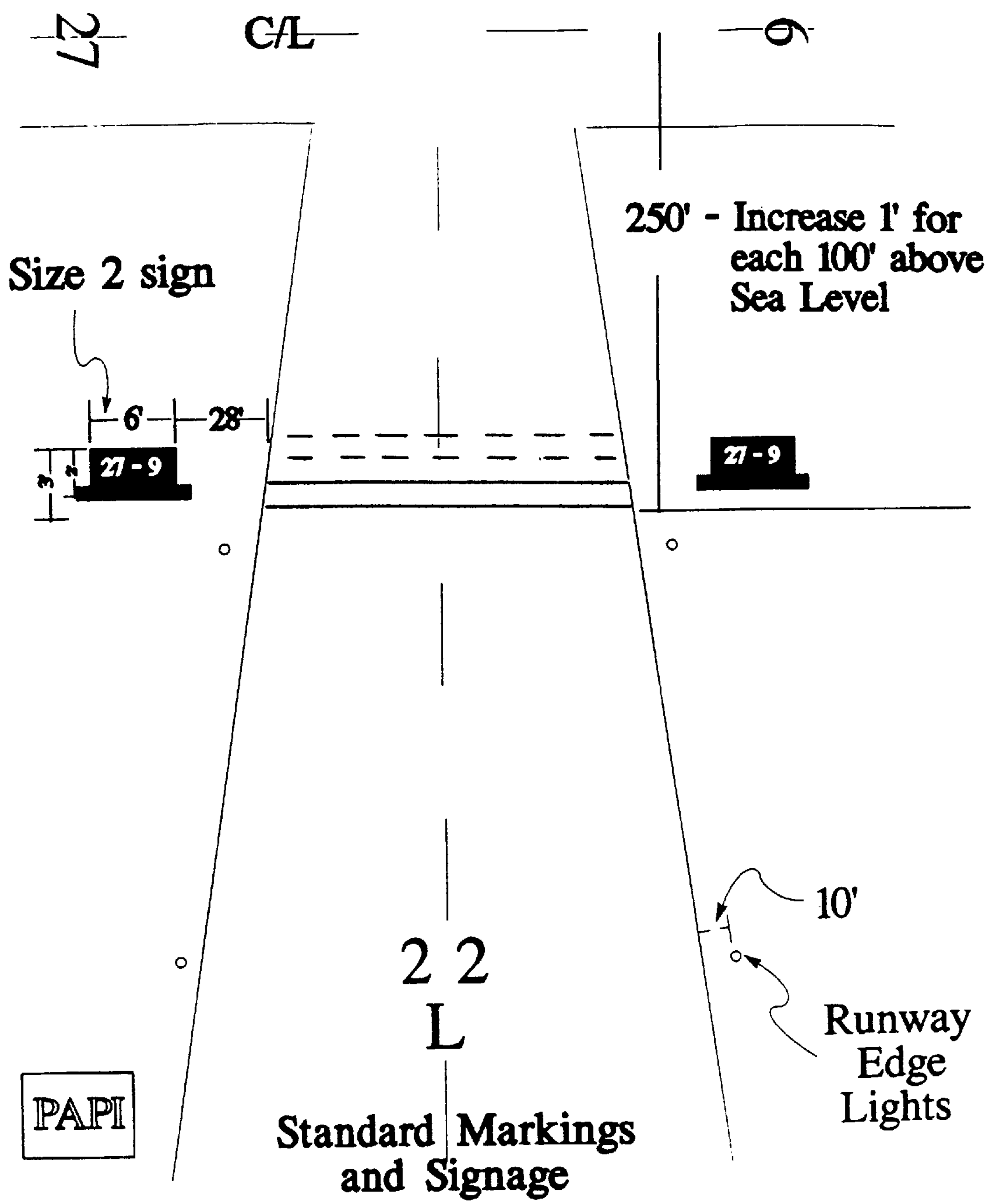

Figure 1-3. Configuration 1

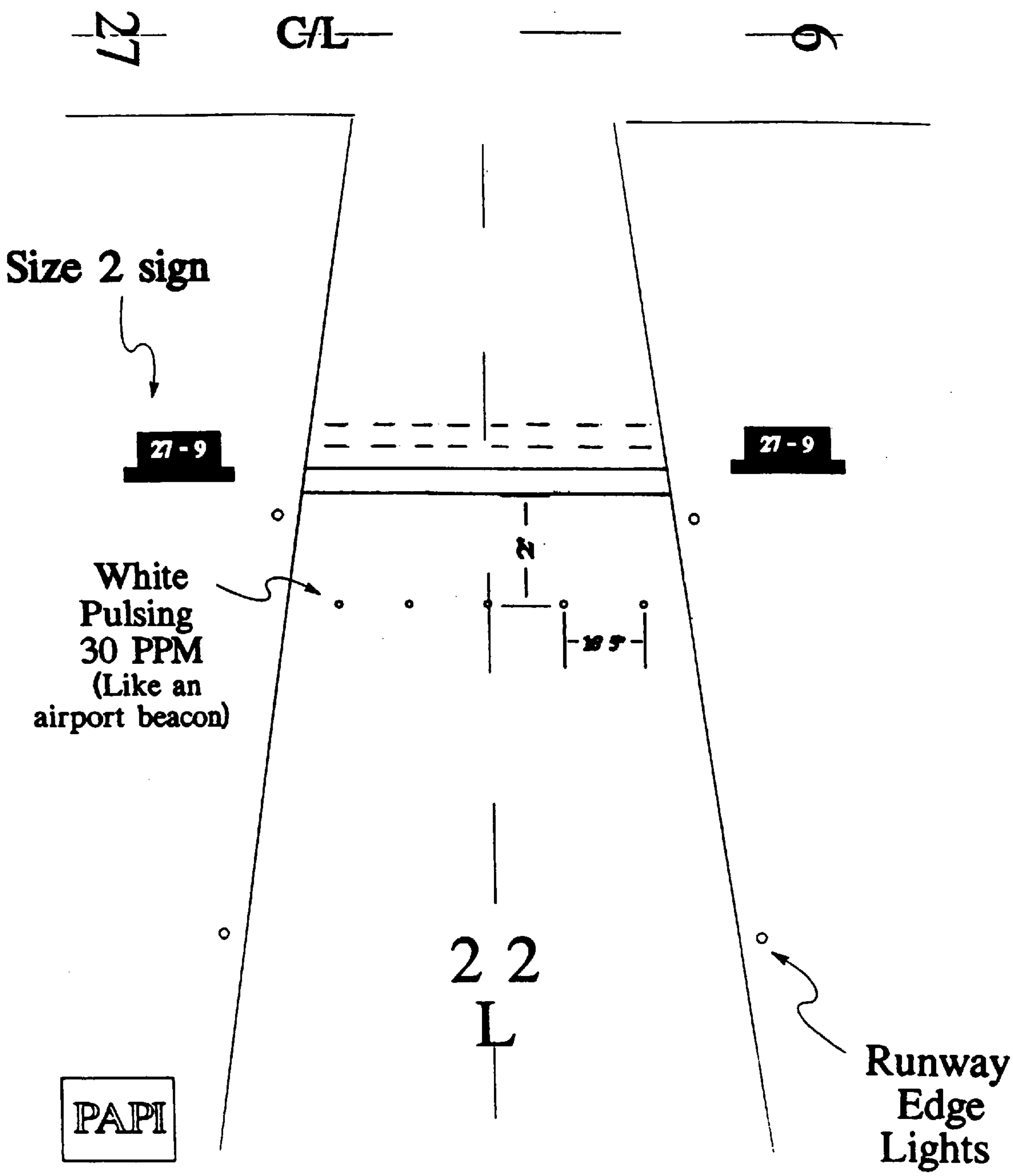

Figure 1-4. Configuration 2

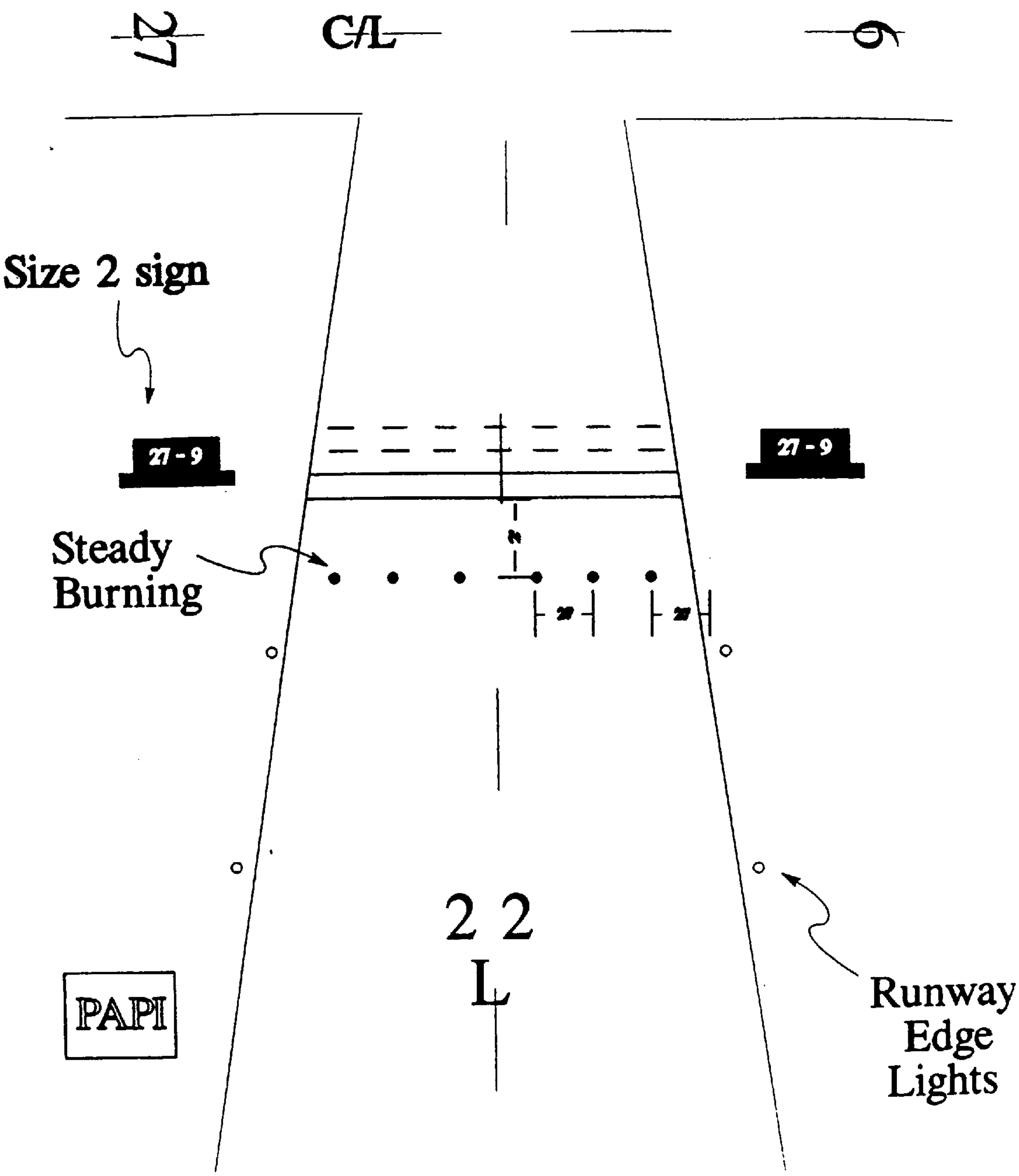

Figure 1-5. Configuration 3

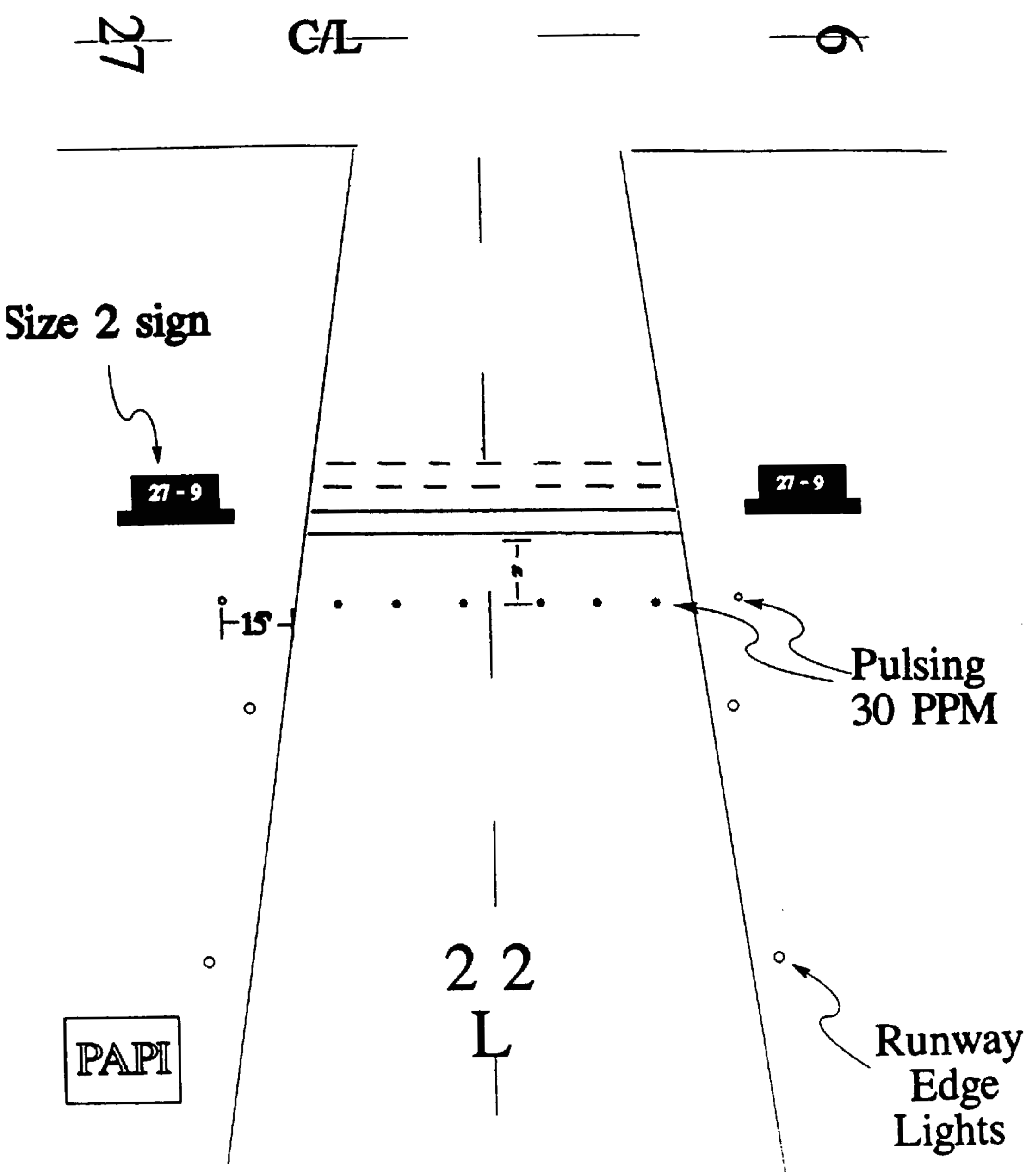

Figure 1-6. Configuration 4

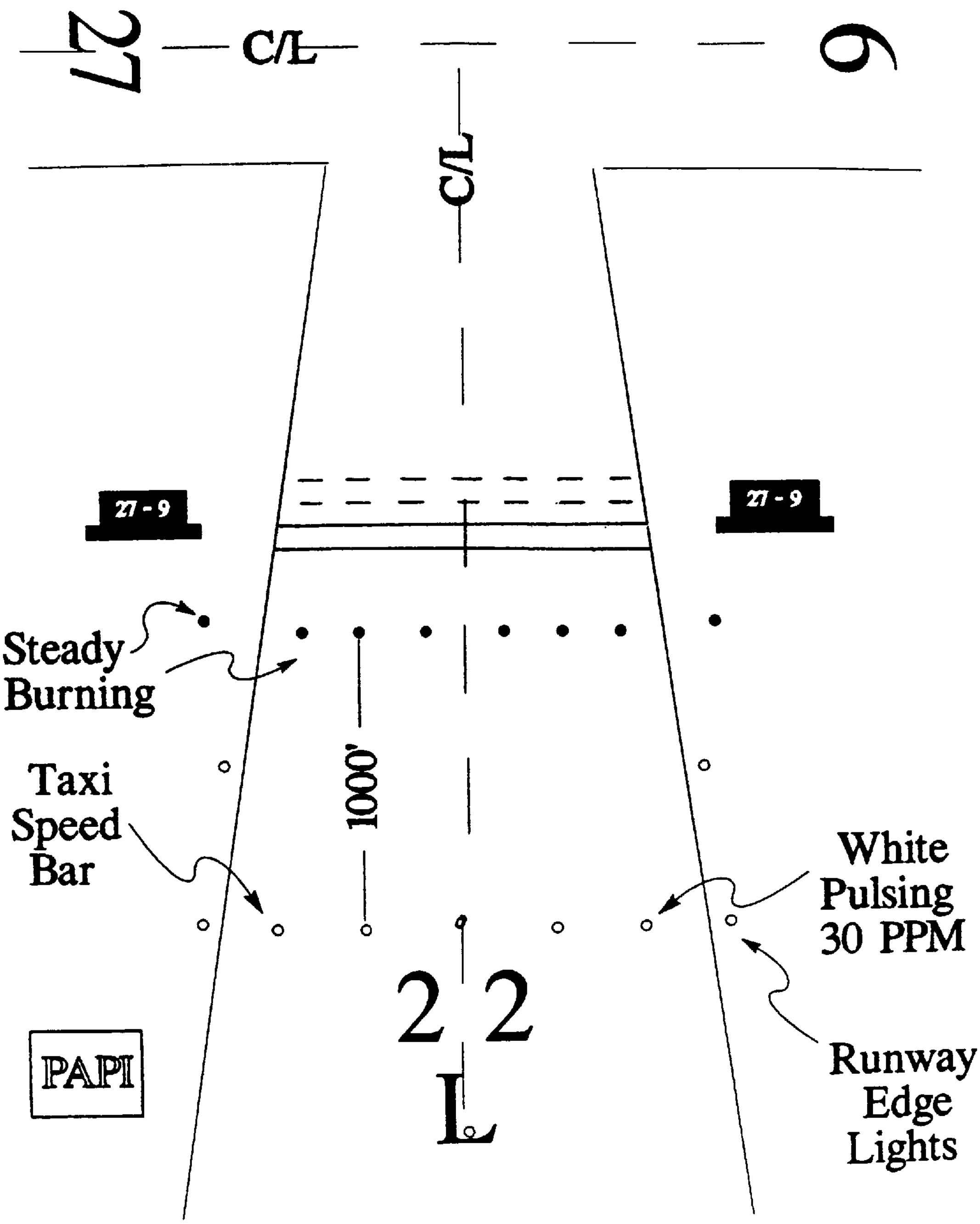

Figure 1-7. Configuration 5

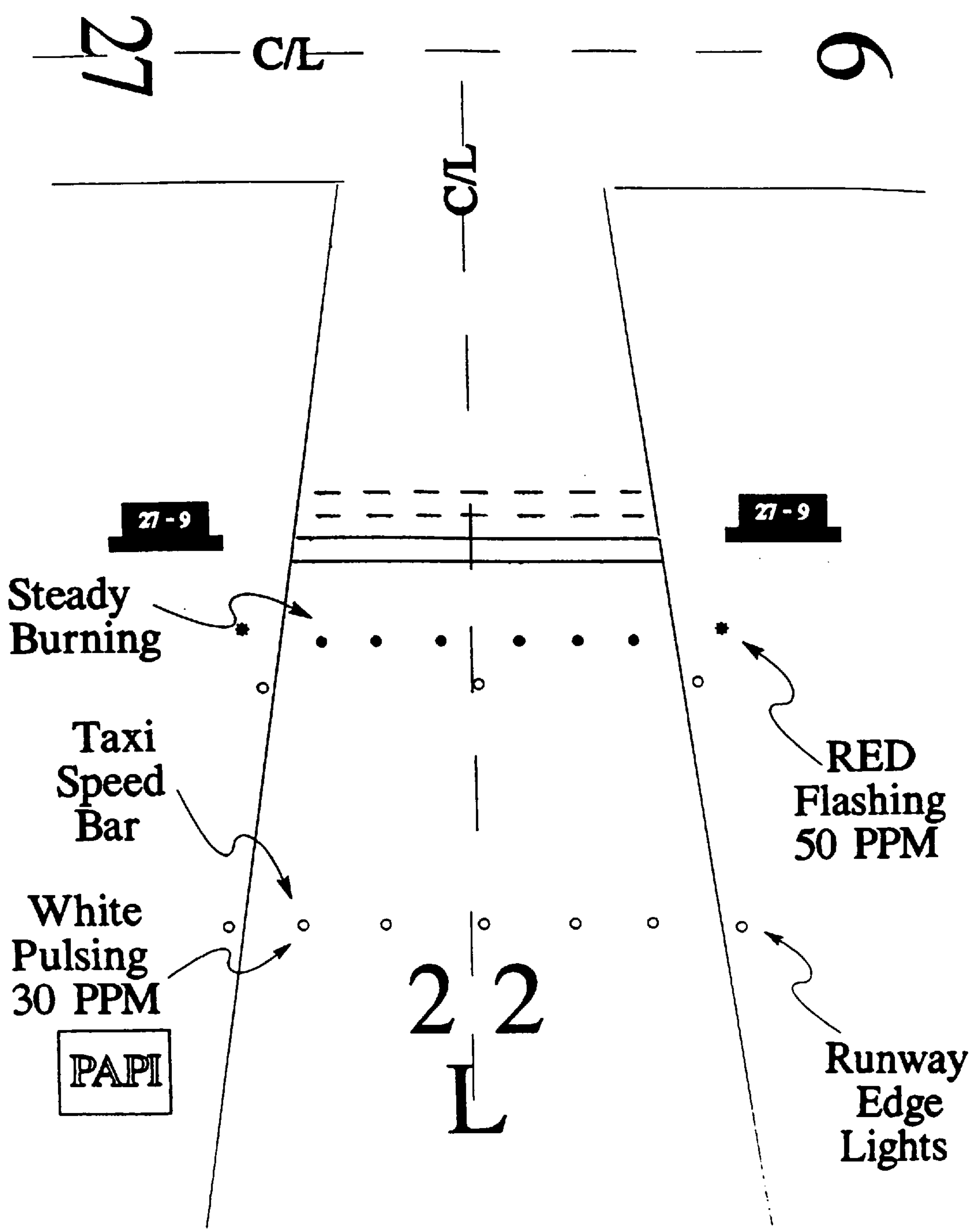

Figure 1-8. Configuration 6

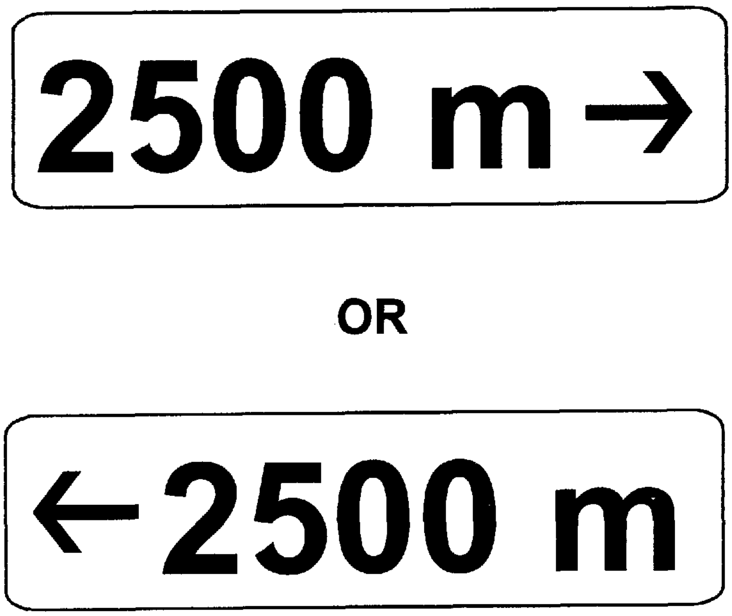

Figure 1-9. Intersection take-off sign

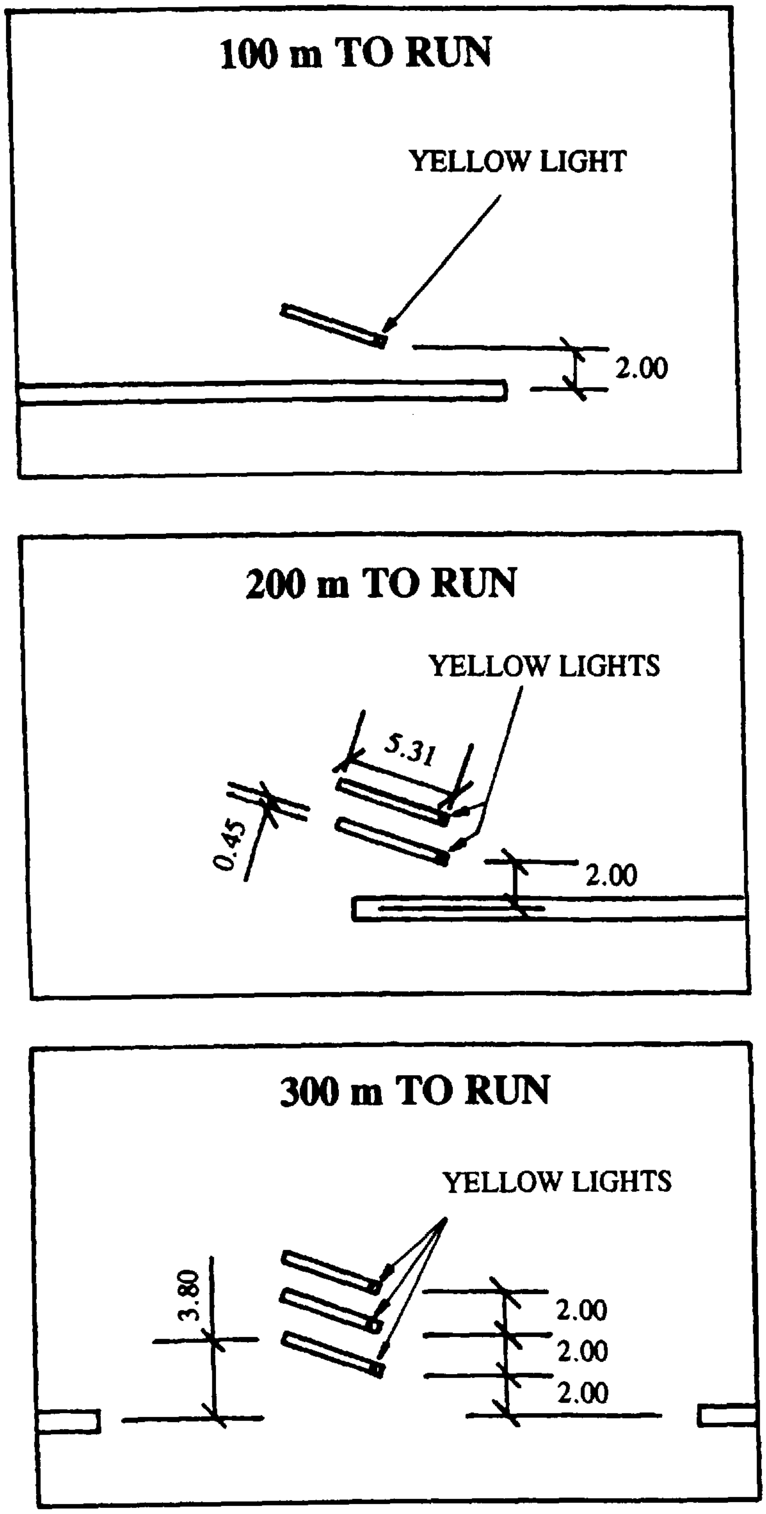

Figure 1-10. Rapid exit taxiway indicator marking and lights dimensions

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APPENDIX A

PROPOSED AMENDMENT TO

INTERNATIONAL STANDARDS AND RECOMMENDED PRACTICES

AERODROMES

ANNEX 14 TO THE CONVENTION ON INTERNATIONAL CIVIL AVIATION

VOLUME I (AERODROME DESIGN AND OPERATIONS)

NOTES ON THE PRESENTATION OF THE PROPOSED AMENDMENT TO ANNEX 14, VOLUME I

The text of the amendment is arranged to show deleted text with a line through it and new text highlighted with grey shading, as shown below:

1.	~~Text to be deleted is shown with a line through it.~~	text to be deleted
2.	New text to be inserted is highlighted with grey shading.	new text to be inserted
3.	~~Text to be deleted is shown with a line through it~~ followed by the replacement text which is highlighted with grey shading.	new text to replace existing text

CHAPTER 1. GENERAL

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1.1 Definitions

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Holding bay. A defined area where aircraft can be held, or bypassed, to facilitate efficient surface movement of aircraft.

Land and hold short position. A designated position on a runway intended for use for land and hold short operations indicating the end of the reduced landing distance available.

. . . . .

Intermediate holding position. A designated position intended for traffic control at which taxiing aircraft and vehicles shall stop and hold when so instructed by the aerodrome control tower, until further cleared to proceed.

Landing area. That part of a movement area intended for the landing or take-off of aircraft.

. . . . .

Runway-holding position. A designated position intended to protect a runway, an obstacle limitation surface, a radio navigation aid sensitive/critical area or the area beyond a land and hold short position at which taxiing aircraft and vehicles shall stop and hold, unless otherwise authorized by the aerodrome control tower.

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Runway strip. A defined area including the runway and stopway, if provided, intended:

a) to reduce the risk of damage to aircraft running off a runway; and

b) to protect aircraft flying over it during take-off or landing operations.

Runway turn pad. A defined area on a land aerodrome adjacent to a runway for the purpose of completing a 180-degree turn onto the runway where no taxiway exists.

. . . . .

Signal area. An area on an aerodrome used for the display of ground signals.

Sign.

a) *Fixed message sign.* A sign presenting only one message.

b) *Variable message sign.* A sign capable of presenting several pre-determined messages or no message, as applicable.

. . . . .

Take-off runway. A runway intended for take-off only.

~~***Taxi-holding position.*** A designated position at which taxiing aircraft and vehicles shall stop and hold position, unless otherwise authorized by the aerodrome control tower.~~

. . . . .

Touchdown zone. The portion of a runway, beyond the threshold, where it is intended landing aeroplanes first contact the runway.

Traffic density

a) *Light.* Where the number of movements in the mean busy hour are not greater than 15 per runway or typically less than 20 total aerodrome movements.

b) *Medium.* Where the number of movements in the mean busy hour are of the order of 16 to 25 per runway or typically between 20 to 35 total aerodrome movements.

c) *Heavy.* Where the number of movements in the mean busy hour are of the order of 26 or more per runway or typically more than 35 total aerodrome movements.

Note.— Either a take-off or a landing constitutes a movement.

CHAPTER 3. PHYSICAL CHARACTERISTICS

3.8 Taxiways

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3.8.2 **Recommendation.—** *Sufficient entrance and exit taxiways for a runway should be provided to expedite the movement of aeroplanes to and from the runway and provision of rapid exit taxiways considered when traffic volumes are high.*

~~*Note.— Where the end of a runway is not served by a taxiway, it may be necessary to provide additional pavement at the end of the runway for the turning of aeroplanes. Such areas may also be useful along the runway to reduce taxiing time and distance for some aeroplanes.*~~

3.11 Holding bays, ~~taxi~~ runway-holding positions, land and hold short positions and road-holding positions

General

3.11.1 **Recommendation.—** *Holding bay(s) should be provided when the traffic ~~volume~~ density is ~~high~~ heavy.*

3.11.2 A ~~taxi~~ runway-holding position or positions shall be established:

a) at an intersection of a taxiway with a runway; and

b) at an intersection of a runway with another runway when the former runway is part of a standard taxi-route.

3.11.3 A ~~taxi~~ runway-holding position shall be established on a taxiway ~~if its location or alignment is~~ located such that a taxiing aircraft or vehicle can infringe an obstacle limitation surface or interfere with the operation of radio navigation aids.

3.11.3A A land and hold short position shall be established on a runway on which it is intended to conduct land and hold short operations.

3.11.4 A road-holding position shall be established at an intersection of a road with a runway.

Location

3.11.5 The distance between a holding bay, ~~taxi~~ runway-holding position established at a taxiway/runway intersection or road-holding position and the centre line of a runway shall be in accordance with Table 3-2 and in the case of a precision approach runway, such that a holding aircraft or vehicle will not interfere with the operation of radio navigation aids.

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Table 3-2. Minimum distance from the runway centre line to a holding bay, ~~taxi-~~ runway-holding position or road-holding position

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3.11.7 **Recommendation.—** *If a holding bay, ~~taxi-~~ runway-holding position or road-holding position for a precision approach runway code number 4 is at a greater elevation compared to the threshold, the distance of 90 m specified in Table 3-2 should be further increased 5 m for every metre the bay or position is higher than the threshold.*

3.11.7A The location of a land and hold short position shall be determined by the competent authority.

3.11.8 The location of a ~~taxi-~~ runway-holding position established at other than a taxiway/runway intersection shall be such that a holding aircraft or vehicle will not infringe the obstacle free zone, approach surface, take-off climb surface or ILS/MLS critical/sensitive area or interfere with the operation of radio navigation aids.

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CHAPTER 5. VISUAL AIDS FOR NAVIGATION

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5.2 Markings

5.2.1 General

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Colour

5.2.1.4 Runway markings shall be white.

Note 1.— It has been found that, on runway surfaces of light colour, the conspicuity of white markings can be improved by outlining them in black.

Note 2.— It is preferable that the risk of uneven friction characteristics on markings be reduced in so far as practicable by the use of a suitable kind of paint.

Note 3.— Markings may consist of solid areas or a series of longitudinal stripes providing an effect equivalent to the solid areas.

5.2.1.5 Taxiway markings and aircraft stand markings shall be yellow.

5.2.1.5A A runway-holding position marking displayed at a land and hold short position shall be yellow.

5.2.1.6 Apron safety lines shall be of a conspicuous colour which shall contrast with that used for aircraft stand markings.

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5.2.7 Runway side stripe marking

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Location

5.2.7.3 **Recommendation.—** *A runway side stripe marking should consist of two stripes, one placed along each edge of the runway with the outer edge of each stripe approximately on the edge of the runway, except that, where the runway is greater than 60 m in width, the stripes should be located 30 m from the runway centre line.*

5.2.7.3A **Recommendation.—** *Where there is a runway turn pad, the runway side stripe marking should be continued between the runway and the runway turn pad.*

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5.2.8 Taxiway centre line marking

Application

5.2.8.1 Taxiway centre line marking shall be provided on a paved taxiway where the code number is 3 or 4 in such a way as to provide guidance from the runway centre line to the point on the apron where aircraft stand markings commence.

5.2.8.1A A taxiway centre line marking shall be provided for guidance from the runway centre line through a runway turn pad to the point where a full turn is to be made.

Note 1.— A full turn requires maximum steering input by the pilot which will result in maximum deflection angle of the nose wheels for most aircraft.

Note 2.— At the point where a full turn is to be made, a full turn is necessary only for the critical aeroplane type using the runway turn pad. Other less critical aeroplanes may not need to make a full turn.

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Location

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5.2.8.5 **Recommendation.—** *At an intersection of a taxiway with a runway where the taxiway serves as an exit from the runway, the taxiway centre line marking should be curved into the runway centre line marking as shown in Figures 5-6 and 5-18. The taxiway centre line marking should be extended parallel to the runway centre line marking for a distance of at least 60 m beyond the point of tangency where the code number is 3 or 4, and for a distance of at least 30 m where the code number is 1 or 2.*

5.2.8.5A **Recommendation.—** *The intersection angle of the taxiway centre line used for guidance through a runway turn pad with the runway centre line should not be greater than 30 degrees. The intersection should be designed with a radius of turn-off curve of at least :*

a) 550 m where the code number is 3 or 4; and

b) 275 m where the code number is 1 or 2.

5.2.8.5B **Recommendation.—** *The taxiway centre line used for guidance through a runway turn pad should be curved from the runway centre line into the turn pad. The taxiway centre line marking should be extended parallel to the runway centre line marking for a distance of at least 60 m beyond the point of tangency where the code number is 3 or 4, and for a distance of at least 30 m where the code number is 1 or 2.*

5.2.8.5C **Recommendation.—** *The straight portions of the taxiway centre line used for guidance through a runway turn pad should be parallel to the outer edge of the runway turn pad. The minimum* *distance between the taxiway centre line and the edge of the runway turn pad should be as given in the following tabulation:*

Code letter	*Distance between taxiway centre line and the runway turn pad edge*
A	6 m
B	8.4 m
C	12 m if the turn pad is intended to be used by aeroplanes with a wheel base less than 18 m
D	15 m if the turn pad is intended to be used by aeroplanes with an outer main gear wheel span of less than 9 m and a wheel base less than 18 m.
	18 m if the turn pad is intended to be used by aeroplanes with an outer main gear wheel span equal to or greater than 9 m.
E	18 m

5.2.8.5D **Recommendation.—** *A taxiway centre line used for guidance through a runway turn pad should guide the aeroplane in such a way as to allow a straight portion of taxiing before the point where a full turn is to be made.*

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5.2.9 ~~Taxi-~~ Runway-holding position marking

Application and location

5.2.9.1 A ~~taxi-~~ runway-holding position marking shall be displayed along a ~~taxi-~~ runway-holding position and a land and hold short position.

Note.— See 5.4.2 concerning the provision of a holding position sign.

Characteristics

5.2.9.2 At an intersection of a taxiway and a non-instrument, non-precision approach or take-off runway, the ~~taxi-~~ runway-holding position marking shall be as shown in Figure 5-6, pattern A.

5.2.9.3 Where a single ~~taxi-~~ runway-holding position is provided at an intersection of a taxiway and a precision approach category I, II or III runway, the ~~taxi-~~ runway-holding position marking shall be as shown in Figure 5-6, pattern A. Where two or three ~~taxi-~~ runway-holding positions are provided at such an intersection, the ~~taxi-~~ runway-holding position marking closer (closest) to the runway shall be as shown in Figure 5-6, pattern A and the markings farther from the runway shall be as shown in Figure 5-6, pattern B.

5.2.9.4 The ~~taxi-~~ runway-holding position marking displayed at a ~~taxi-~~ runway-holding position established in accordance with 3.11.3 shall be as shown in Figure 5-6, pattern A.

Editorial Note.— Make the following changes to text within Figure 5-6

~~TAXI~~RUNWAY-HOLDING POSITION MARKING

~~TAXIWAY INTERSECTION~~ INTERMEDIATE HOLDING POSITION MARKING

5.2.9.5 **Recommendation.—** *Where a pattern B ~~taxi-~~runway-holding position marking is located on an area where it would exceed 60 m in length, the term "CAT II" or "CAT III" as appropriate should be marked on the surface at the ends of the ~~taxi-~~runway-holding position marking and at equal intervals of 45 m maximum between successive marks. The letters should be not less than 1.8 m high and should be placed not more than 0.9 m beyond the holding position marking.*

5.2.9.6 The ~~taxi-~~runway-holding position marking displayed ~~at a runway/runway intersection~~on a runway shall be perpendicular to the centre line of the runway ~~forming part of the standard taxi route~~. The pattern of the marking shall conform to that shown in Figure 5-6, pattern A.

5.2.9.7 The runway-holding position marking displayed at a land and hold short position shall be perpendicular to the centre line of the runway on which the land and hold short operation is intended to take place. The pattern of the marking shall conform to that shown in Figure 5-6, Pattern A or Pattern B.

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5.2.10 ~~Taxiway intersection~~ Intermediate holding position marking

Application

5.2.10.1 **Recommendation.—** *A~~n~~ ~~taxiway intersection~~ intermediate holding position marking should be displayed at ~~an intersection of two paved taxiways~~ any point other than a runway-holding position where it is desired to designate a specific holding limit.*

5.2.10.1A **Recommendation.—** *An intermediate holding position marking should be displayed at the exit boundary of a remote de/anti-icing pad not located on a taxiway.*

Location

5.2.10.2 **Recommendation.—** *A~~n~~ ~~taxiway intersection~~ intermediate holding position marking should be located across a taxiway at sufficient distance from the near edge of an intersecting taxiway to ensure safe clearance between taxiing aircraft. It should be coincident with a stop bar or ~~clearance bar~~ intermediate holding position lights, where provided.*

5.2.10.2A The distance between an intermediate holding position marking at the exit boundary of a remote de/anti-icing pad and the centre line of a parallel taxiway shall be in accordance with Table 3-1, Column 11.

Characteristics

5.2.10.3 A~~n taxiway intersection~~ intermediate holding position marking shall consist of a single broken line as shown in Figure 5-6.

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5.2.12 Aircraft stand markings

Note.— Guidance on the layout of aircraft stand markings is contained in the Aerodrome Design Manual, *Part 4.*

Application

5.2.12.1 **Recommendation.—** *Aircraft stand markings should be provided for designated parking positions on a paved apron and on a de/anti-icing pad.*

Location

5.2.12.2 **Recommendation.—** *Aircraft stand markings on a paved apron and on a de/anti-icing pad should be located so as to provide the clearances specified in 3.12.6 and in 3.12A respectively when the nose wheel follows the stand marking.*

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5.2.14 Road-holding position marking

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Insert new text as follows:

5.2.14A Mandatory instruction marking

Note.— Guidance on mandatory instruction marking is given in the Aerodrome Design Manual, *Part 4.*

Application

5.2.14A.1 **Recommendation.—** *Where operationally required, such as on taxiways exceeding 60 m in width, a mandatory instruction sign should be supplemented by a mandatory instruction marking.*

5.2.14A.2 Where it is impracticable to install a mandatory instruction sign in accordance with 5.4.2.1, a mandatory instruction marking shall be provided.

Location

5.2.14A.3 The mandatory instruction marking shall be located to the left of the taxiway centre line marking and on the holding side of the runway-holding position marking. The nearest edge of the marking shall be not closer than 1 m to the runway-holding position marking or the taxiway centre line marking. See Figure 5-7A.

5.2.14A.4 **Recommendation.—** *Except where operationally required, mandatory instruction markings should not be located on a runway.*

Characteristics

5.2.14A.5 A mandatory instruction marking shall consist of an inscription in white on a red background. The inscription shall provide information identical to that of the associated mandatory instruction sign.

5.2.14A.6 Where there is insufficient contrast between the marking and the pavement surface, the mandatory instruction marking shall include an appropriate border, preferably white or black.

5.2.14A.7 **Recommendation.—** *The character height should be 4 m. The inscriptions should be in the form and proportions shown in Appendix 3.*

5.2.14A.8 **Recommendation.—** *The background should be rectangular and extend a minimum of 0.5 m laterally and vertically beyond the extremities of the inscription.*

End of new text

. . . . .

Insert new figure as follows:

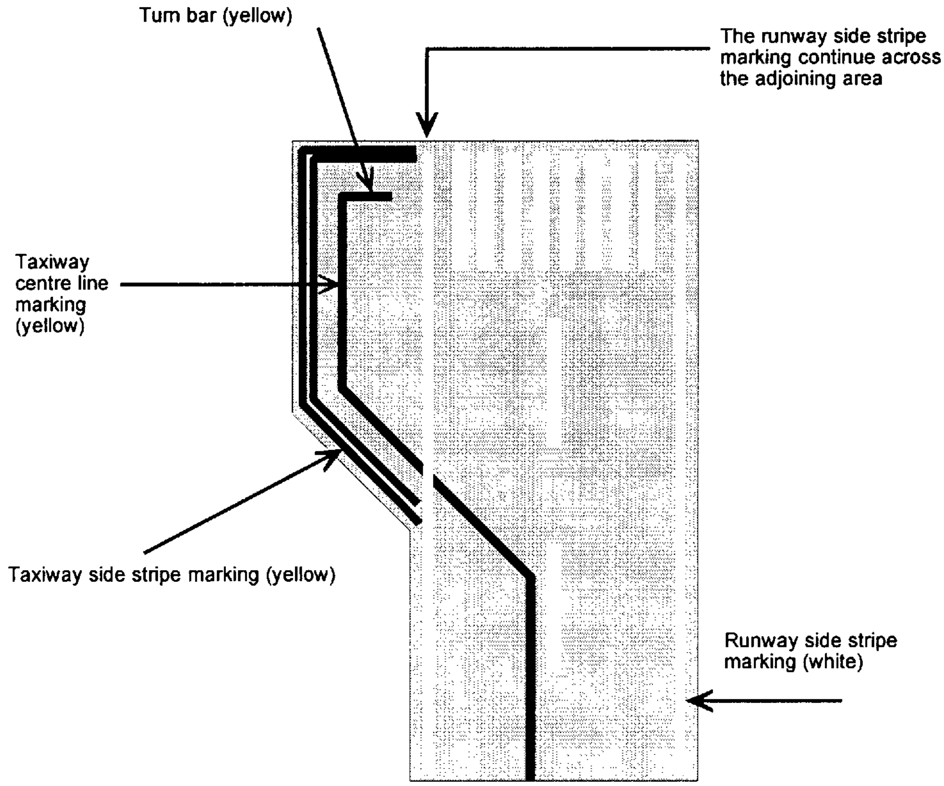


Figure 5-5B. Runway turn pad markings (not to scale)

End of new figure

Insert new figure as follows:

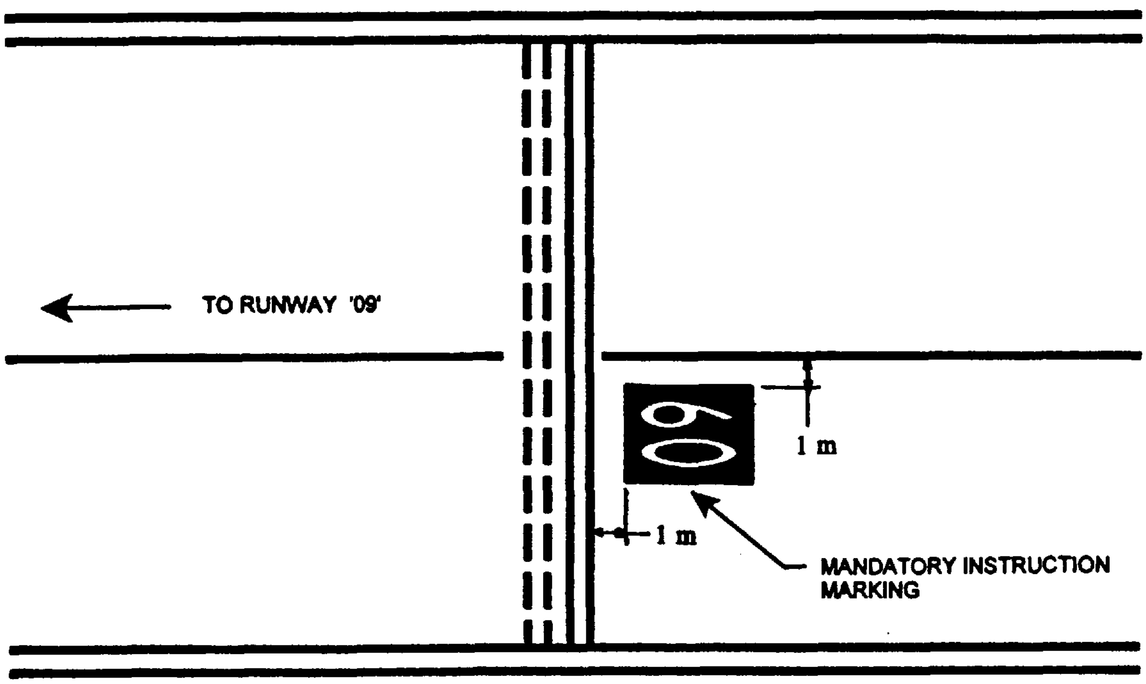


Figure 5-7A. Mandatory instruction marking

Insert new text as follows:

5.3 Lights

. . . . .

5.3.5 Visual approach slope indicator systems

Application

5.3.5.1 A visual approach slope indicator system shall be provided to serve the approach to a runway whether or not the runway is served by other visual approach aids or by non-visual aids, where one or more of the following conditions exist:

a) the runway is used by turbojet or other aeroplanes with similar approach guidance requirements;

. . . . .

d) physical conditions at either end of the runway present a serious hazard in the event of an aeroplane undershooting or overrunning the runway; ~~and~~

e) terrain or prevalent meteorological conditions are such that the aeroplane may be subjected to unusual turbulence during approach~~.~~; and

f) the runway is intended to be used for land and hold short operations.

. . . . .

5.3.11 Runway end lights
(see Figure 5-15)

. . . . .

5.3.11.5 Runway end lights on a precision approach runway shall be in accordance with the specifications of Appendix 2, Figure 2.9.

Insert new text as follows:

5.3.11A Land and hold short lights

Application

5.3.11A.1 Land and hold short lights, Configuration A, shall be provided on a runway that is intended to be used for land and hold short operations where the lights are intended to be controlled on a movement-by-movement basis.

5.3.11A.2 Land and hold short lights, Configuration A, shall be switched off when land and hold short operations are not being conducted.

5.3.11A.3 Land and hold short lights, Configuration B, shall be provided on a runway that is intended to be used for land and hold short operations where control of the lights on a movement-by-movement basis is not practicable.

5.3.11A.4 **Recommendation.—** *Where land and hold short operations are not mixed with other, full length, operations and no need exists for the landing aircraft to cross the land and hold short position, land and hold short lights, Configuration A, should be provided.*

Location

5.3.11A.5 A land and hold short position bar shall be located across the runway as near to the land and hold short position as possible, in any case not beyond, and not more than 3 m before the land and hold short position.

5.3.11A.6 The elevated red lights at each end of a land and hold short position bar shall be located 2 m outboard of the line of runway edge lights where provided or 2 m outboard of the runway edge where edge lights are not provided.

5.3.11A.7 A land and hold short alert bar shall be located across the runway 300 m prior to the land and hold short position.

Characteristics

5.3.11A.8 Land and hold short lights, Configuration A, shall consist of:

a) a land and hold short position bar; and
b) a land and hold short alert bar.

5.3.11A.9 Land and hold short lights, Configuration B, shall consist of:

a) runway guard lights, Configuration A; and
b) a land and hold short alert bar.

Note.— See 5.3.19 for runway guard light specifications.

5.3.11A.10 A land and hold short position bar shall consist of:

a) at least six fixed unidirectional lights showing red in the direction of approach to the land and hold short position equally spaced at intervals not greater than 6 m across the runway and symmetrically located about the runway centre line; and

b) two elevated flashing lights, one at each end of the bar, showing red in the direction of approach to the land and hold short position.

5.3.11A.11 The intensity and beam spread of the lights shall be adequate for the conditions of visibility and ambient light in which land and hold short operations are conducted.

5.3.11A.12 **Recommendation.—** *Land and hold short position bar lights should be in accordance with the specifications of Appendix 2, Figure 2.9.*

5.3.11A.13 The two elevated lights shall be illuminated in unison between 45 and 55 cycles per minute and the light illumination and suppression periods shall be equal.

5.3.11A.14 Land and hold short position bars shall be individually switchable.

Note.— A land and hold short position bar is switched on to indicate that aircraft must not proceed past that position, and switched off to indicate that aircraft may proceed.

5.3.11A.15 A land and hold short alert bar shall consist of at least 6 flashing unidirectional lights showing white in the direction of approach to the land and hold short position equally spaced at intervals not greater than 6 m across the runway and symmetrically located about the runway centre line.

5.3.11A.16 The intensity and beam spread of the lights shall be adequate for the conditions of visibility and ambient light in which land and hold short operations are conducted.

5.3.11A.17 **Recommendation.—** *Land and hold short alert bar lights should be in accordance with the specification of Appendix 2, Figure 2.6.*

5.3.11A.18 The land and hold short alert bar lights shall be illuminated in unison between 25 and 35 cycles per minute.

5.3.11A.19 **Recommendation.—** *The land and hold short alert bar light illumination period should be approximately 2/3 and light suppression period should be approximately 1/3 of the total period of each cycle.*

End of new text

. . . . .

5.3.15 Taxiway centre line lights

Application

5.3.15.1 Taxiway centre line lights shall be provided on an exit taxiway, taxiway, de/anti-icing pad and apron intended for use in runway visual range conditions less than a value of 350 m in such a manner as to provide continuous guidance ~~from~~ between the runway centre line ~~to the point on the apron where aircraft commence manoeuvring for parking,~~ and aircraft stand markings, except that these lights need not be provided where ~~there is a low volume of traffic~~ the traffic density is light and taxiway edge lights and centre line marking provide adequate guidance.

5.3.15.2 **Recommendation.—** *Taxiway centre line lights should be provided on a taxiway intended for use at night in runway visual range conditions of 350 m or greater, and particularly on complex taxiway intersections and exit taxiways, except that these lights need not be provided where ~~there~~ the traffic density is ~~a low volume of traffic~~ light and taxiway edge lights and centre line marking provide adequate guidance.*

Note.— Where there may be a need to delineate the edges of a taxiway, e.g. on a rapid exit taxiway, narrow taxiway or in snow conditions, this may be done with taxiway edge lights or markers.

5.3.15.2A Taxiway centre line lights shall be provided along the taxiway centre line of a runway turn pad intended for use in runway visual range conditions less than a value of 350 m. The taxiway centre line lights shall provide continuous guidance from the runway centre line through the runway turn pad to the point where a full turn is to be made.

5.3.15.2B **Recommendation.—** *Taxiway centre line lights should be provided along the taxiway centre line of a runway turn pad intended for use at night.*

5.3.15.3 Taxiway centre line lights shall be provided on a runway forming part of a standard taxi-route and intended for taxiing in runway visual range conditions less than a value of 350 m, except that these lights need not be provided where ~~there~~ the traffic density is ~~a low volume of traffic~~ light and taxiway edge lights and centre line marking provide adequate guidance.

Note.— See 8.2.3 for provisions concerning the interlocking of runway and taxiway lighting systems.

Characteristics

5.3.15.4 Taxiway centre line lights on a taxiway other than an exit taxiway, on a runway turn pad and on a runway forming part of a standard taxi-route shall be fixed lights showing green with beam dimensions such that the light is visible only from aeroplanes on or in the vicinity of the taxiway or the runway turn pad.

. . . . .

5.3.15.6 Taxiway centre line lights shall be in accordance with the specifications of:

a) Appendix 2, Figure 2.13, 2.14, or 2.15 for taxiways intended for use in runway visual range conditions of less than a value of 350 m; and

b) Appendix 2, Figure 2.16 or 2.17 for other taxiways.

5.3.15.6A Taxiway centre line lights intended to provide guidance through a runway turn pad shall be in accordance with Appendix 2, Figure 2.13, 2.14 or 2.15.

. . . . .

Taxiway centre line lights on taxiways and runway turn pads

Location

5.3.15.8 **Recommendation.—** *Taxiway centre line lights on a straight section of a taxiway should be spaced at longitudinal intervals of not more than 30 m, except that:*

a) larger intervals not exceeding 60 m may be used where, because of the prevailing meteorological conditions, adequate guidance is provided by such spacing;

b) *intervals of less than 30 m should be provided on short straight sections;~~-and~~*

c) *on a taxiway intended for use in RVR conditions of less than a value of 350 m, the longitudinal spacing should not exceed 15 m~~.~~; and*

d) on a runway turn pad the longitudinal spacing should not exceed 15 m.

. . . . .

5.3.15.10A **Recommendation.—** *Taxiway centre line lights on a runway turn pad curve should not exceed a spacing of 7.5 m.*

. . . . .

Insert new text as follows:

5.3.15A Turn bar lights

Application

5.3.15A.1 Turn bar lights shall be provided in a runway turn pad at the point where a full turn is to be made from the runway turn pad onto the runway.

Note.— A full turn requires maximum steering input by the pilot which will result in maximum deflection angle of the nose wheels for most aircraft.

Location

5.3.15A.2 Turn bar lights shall be located at the end of and perpendicular to the final segment of taxiway centre line lights in a runway turn pad where a full turn is to be made. The distance from the edge of the turn pad shall be in accordance with the values given in 5.2.8.5C.

Note.— Guidance on the location of turn bar lights is given in the Aerodrome Design Manual, *Part 4.*

Characteristics

5.3.15A.3 Turn bar lights shall consist of three unidirectional taxiway centre line lights spaced at 2 m intervals at right angle to the final segment of taxiway centre line lights in the direction of the turn into the runway and shall be oriented to show green toward an aircraft aligned on the final segment of taxiway centre line lights approaching the point where a full turn is to be made.

5.3.15A.4 Turn bar lights shall be in accordance with the specifications of Appendix 2, Figure 2.13, 2.14 or 2.15.

End of new text

5.3.16 Taxiway edge lights

Application

5.3.16.1 ~~Taxiway edge lights shall be provided on~~ Except as recommended in 5.3.18A, taxiway edge lights shall be provided to mark the extremities of a runway turn pad, holding bay, apron, de/anti-icing pad, etc. intended for use at night and on a taxiway not provided with taxiway centre line lights and intended for use at night, except that taxiway edge lights need not be provided where, considering the nature of the operations, adequate guidance can be achieved by surface illumination or other means.

Note.— See 5.5.5 for taxiway edge markers.

. . . . .

Location

5.3.16.3 **Recommendation.—** *Taxiway edge lights on a straight section of a taxiway and on a runway forming part of a standard taxi-route should be spaced at uniform longitudinal intervals of not more than 60 m. The lights on a curve should be spaced at intervals less than 60 m so that a clear indication of the curve is provided.*

5.3.16.3A **Recommendation.—** *Taxiway edge lights on a straight section of a runway turn pad should be spaced at uniform longitudinal intervals of not more than 30 m. The lights on a curve should be spaced at intervals less than 30 m so that a clear indication of the curve is provided.*

5.3.16.4 **Recommendation.—** *The lights should be located as near as practicable to the edges of the taxiway, runway turn pad, holding bay, apron or runway, etc. or outside the edges at a distance of not more than 3 m.*

. . . . .

Make the following change to text in the Legend of Figure 5-17 on page 72:

~~Taxiway intersection~~ Intermediate holding position light (unidirectional)

. . . . .

5.3.17 Stop bars

. . . . .

5.3.17.1 A stop bar shall be provided at every ~~taxi~~ runway-holding position serving a runway when it is intended that the runway will be used in runway visual range conditions less than a value of 350 m, except where:

a) appropriate aids and procedures are available to assist in preventing inadvertent incursions of aircraft and vehicles onto the runway; or

b) operational procedures exist to limit, in runway visual range conditions less than a value of 550 m, the number of:

1) aircraft on the manoeuvring area to one at a time; and

2) vehicles on the manoeuvring area to the essential minimum.

5.3.17.2 **Recommendation.—** *A stop bar should be provided at every ~~taxi~~ runway-holding position serving a runway when it is intended that the runway will be used in runway visual range conditions of values between 350 m and 550 m, except where:*

. . . . .

5.3.17.7 Stop bars shall consist of lights spaced at intervals of 3 m across the taxiway, showing red in the intended direction(s) of approach to the intersection or ~~taxi~~ runway-holding position.

5.3.17.8 Stop bars installed at a ~~taxi~~ runway-holding position shall be unidirectional and shall show red in the direction of approach to the runway.

. . . . .

5.3.18 ~~Taxiway intersection~~ Intermediate holding position lights

Note.— See 5.2.10 for specifications on ~~taxiway intersection~~ intermediate holding position marking.

Application

5.3.18.1 Intermediate holding position lights shall be provided at an intermediate holding position intended for use in RVR conditions less than a value of 350 m except where a stop bar has been installed.

5.3.18.~~1~~2 **Recommendation.—** *~~Taxiway intersection~~ Intermediate holding position lights should be provided at ~~a taxiway intersection~~ any point other than a runway-holding position where it is ~~desirable to define a specific aeroplane holding limit~~ desired to designate a specific holding limit and there is no need for stop-and-go signals as provided by a stop bar.*

Location

5.3.18.~~2~~3 ~~Taxiway intersection~~ Where intermediate holding position lights are established at a taxiway/taxiway intersection, they shall be located at a point between 30 m to 60 m from the near edge of the intersecting taxiway.

Characteristics

5.3.18.~~3~~4 ~~Taxiway intersection~~ Intermediate holding position lights shall consist of ~~at least~~ three fixed unidirectional lights showing yellow in the direction of approach to the ~~intersection~~ intermediate holding position with a light distribution similar to taxiway centre line lights if provided. The lights shall be disposed symmetrically about, and at ~~90°~~ right angle to, the taxiway or taxi-route centre line, with individual lights spaced 1.5 m apart.

5.3.18A De/anti-icing pad exit lights

Application

5.3.18A.1 **Recommendation.—** *De/anti-icing pad exit lights should be provided at the exit boundary of a remote de/anti-icing pad not located on a taxiway.*

Location

5.3.18A.2 De/anti-icing pad exit lights shall be located 0.6 m inward of the intermediate holding position marking displayed at the exit boundary of a remote de/anti-icing pad.

Characteristics

5.3.18A.3 De/anti-icing pad exit lights shall consist of in-pavement fixed unidirectional lights showing yellow in the direction of the approach to the exiting boundary with a light distribution similar to taxiway centre line lights. The individual lights shall be spaced 6.0 m apart.

. . . . .

5.3.19 Runway guard lights

Note.— There are two standard configurations of runway guard lights as illustrated in Figure 5-19.

Application

5.3.19.1 Runway guard lights, Configuration A, shall be provided at each land and hold short position where land and hold short lights, Configuration B, are specified and at each taxiway/runway intersection associated with a runway intended for use in:

a) runway visual range conditions less than a value of 550 m where a stop bar is not installed; and

b) runway visual range conditions of values between 550 m and 1 200 m where the traffic density is ~~high~~ heavy.

~~*Note.— See the* Manual of Surface Movement Guidance and Control Systems (SMGCS) *for the definition of traffic conditions.*~~

5.3.19.2 **Recommendation.—** *Runway guard lights, Configuration A, should be provided at each taxiway/runway intersection associated with a runway intended for use in:*

a) *runway visual range conditions of values less than a value of 550 m where a stop bar is installed; and*

b) *runway visual range conditions of values between 550 m and 1 200 m where the traffic density is medium or ~~low~~ light.*

. . . . .

Location

5.3.19.3A Runway guard lights, Configuration A, shall be located at the land and hold short position at each side of the runway 2 m outboard of the line of runway edge lights where provided or 2 m outboard of the runway edge where edge lights are not provided.

5.3.19.4 Runway guard lights, Configuration A, shall be located at each side of the taxiway at a distance from the runway centre line not less than that specified for a take-off runway in Table 3-2.

5.3.19.5 Runway guard lights, Configuration B, shall be located across the taxiway at a distance from the runway centre line not less than that specified for a take-off runway in Table 3-2.

. . . . .

5.3.22 Aircraft stand manoeuvring guidance lights

Application

5.3.22.1 **Recommendation.—** *Aircraft stand manoeuvring guidance lights should be provided to facilitate the positioning of an aircraft on an aircraft stand on a paved apron and on a de/anti-icing pad intended for use in poor visibility conditions, unless adequate guidance is provided by other means.*

. . . . .

Insert new figure as follows:

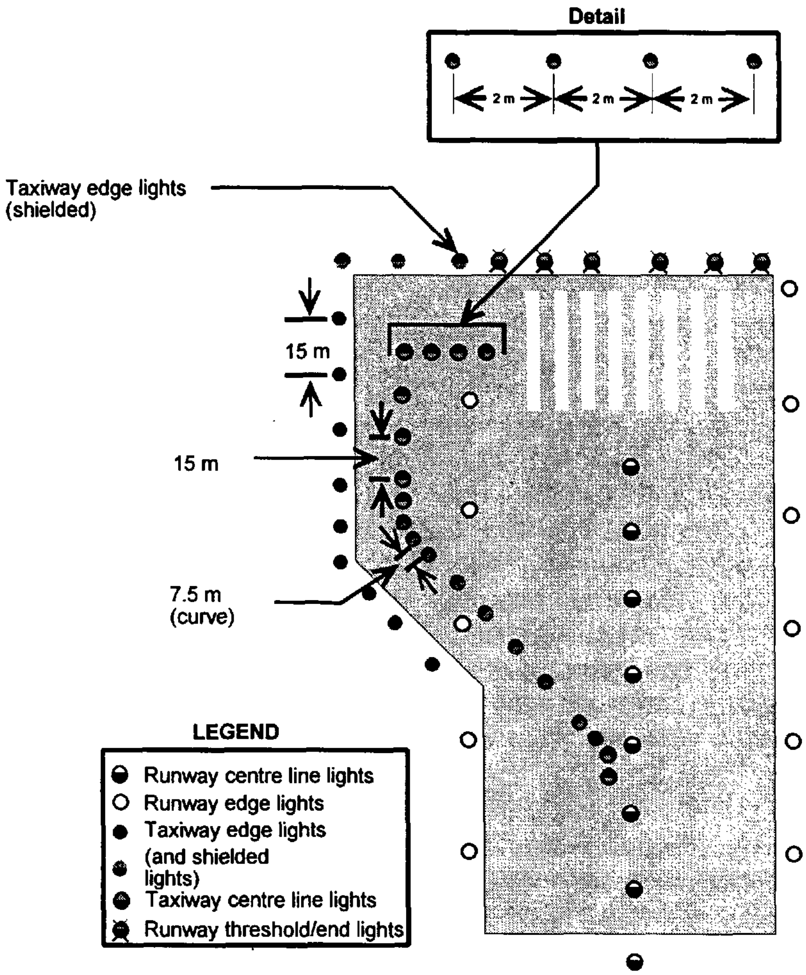


Figure 5-18A. Runway turn pad lights (not to scale)

End of new figure

5.4 Signs

5.4.1 General

Note.— Signs shall be either fixed message signs or variable message signs. Guidance on signs is contained in the Aerodrome Design Manual, *Part 4.*

Application

5.4.1.1 Signs shall be provided to convey a mandatory instruction, information on a specific location or destination on a movement area or to provide other information to meet the requirements of 8.9.1.

Note.— See 5.2.15 for specifications on information marking.

5.4.1.1A **Recommendation.—** *A variable message sign should be provided where:*

a) the instruction or information displayed on the sign is relevant only during a certain period of time; and/or

b) there is a need for variable pre-determined information to be displayed on the sign, to meet the requirements of 8.9.1.

Characteristics

5.4.1.2 Signs shall be frangible. Those located near a runway or taxiway shall be sufficiently low to preserve clearance for propellers and the engine pods of jet aircraft. The installed height of the sign shall not exceed the dimension shown in the appropriate column of Table 5-4.

5.4.1.3 Signs shall be rectangular, as shown in Figures 5-20 and 5-21 with the longer side horizontal.

5.4.1.4 The only signs on the movement area utilizing red shall be mandatory instruction signs.

5.4.1.5 The inscriptions on a sign shall be in accordance with the provisions of Appendix 4.

5.4.1.6 Signs shall be illuminated in accordance with the provisions of Appendix 4 when intended for use:

a) in runway visual range conditions less than a value of 800 m; or

b) at night in association with instrument runways; or

c) at night in association with non-instrument runways where the code number is 3 or 4.

5.4.1.7 Signs shall be retroreflective and/or illuminated in accordance with the provisions of Appendix 4 when intended for use at night in association with non-instrument runways where the code number is 1 or 2.

5.4.1.8 A variable message sign shall show a blank face when not in use.

5.4.1.9 In case of failure, a variable message sign shall not provide information that could lead to unsafe action from the pilot.

5.4.1.10 **Recommendation.—** *The time interval to change from one message to another on a variable message sign should be as short as practicable and should not exceed 5 seconds.*

. . . . .

5.4.2 Mandatory instruction signs

. . . . .

5.4.2.2 Mandatory instruction signs shall include runway designation signs, category I, II or III holding position signs, ~~taxi-~~ runway-holding position signs, road-holding position signs and NO ENTRY signs.

Note.— See 5.4.7 for specifications on road-holding position signs.

5.4.2.3 A pattern "A" ~~taxi-~~runway-holding position marking shall be supplemented at a taxiway/runway intersection or a runway/runway intersection with a runway designation sign.

5.4.2.4 A pattern "B" ~~taxi-~~ runway-holding position marking shall be supplemented with a category I, II or III holding position sign.

Note.— See 5.2.9 for ~~taxi~~ runway-holding position marking.

5.4.2.5 **Recommendation.—** *A runway designation sign at a runway-holding position located at a taxiway/runway intersection should be supplemented with a location sign in the outboard (farthest from the taxiway) position, as appropriate.*

5.4.2.6 A NO ENTRY sign shall be provided when entry into an area is prohibited.

5.4.2.7 A runway designation sign at a taxiway/runway intersection shall be located at least on the left side of a taxiway facing the direction of approach to the runway. Where practicable a runway designation sign shall be located on each side of the taxiway.

5.4.2.7A Where land and hold short operations are intended to take place, the appropriate mandatory sign shall be located on each side of the runway-holding position marking facing the direction of approach to the land and hold short position.

5.4.2.8 NO ENTRY sign shall be located at the beginning of the area to which entrance is prohibited at least on the left-hand side of the taxiway as viewed by the pilot. Where practicable, a NO ENTRY sign shall be located on each side of the taxiway.

5.4.2.9 A category I, II or III holding position sign shall be located on each side of the holding position marking facing the direction of the approach to the critical area.

5.4.2.10 A ~~taxi~~ runway-holding position sign shall be located at least on the left-side of the ~~taxi~~ runway-holding position established in accordance with 3.11.3, facing the approach to the obstacle limitation surface or ILS/MLS critical/sensitive area, as appropriate. Where practicable, a holding position sign shall be located on each side of the ~~taxi~~ runway-holding position.

. . . . .

5.4.2.15 The inscription on a ~~taxi~~ runway-holding position sign established in accordance with 3.11.3 shall consist of the taxiway designation and a number.

5.4.2.16 Where appropriate, the following inscriptions/symbol shall be used:

Inscription/ symbol	*Use*
25 CAT I (Example)	To indicate a category I ~~taxi~~ runway-holding position at the threshold of runway 25
25 CAT II (Example)	To indicate a category II ~~taxi~~ runway-holding position at the threshold of runway 25
25 CAT III (Example)	To indicate a category III ~~taxi~~ runway-holding position at the threshold of runway 25
25 CAT II/III (Example)	To indicate a joint category II/III ~~taxi~~ runway-holding position at the threshold of runway 25
NO ENTRY symbol	To indicate that entry to an area is prohibited
Runway designation of a runway extremity	To indicate a ~~taxi~~ runway-holding position at a runway extremity
OR	
Runway designation of both extremities of a runway	To indicate a ~~taxi~~ runway-holding position located at other taxiway/runway intersections or runway/runway intersections

B2 (Example)	To indicate a ~~taxi~~ runway holding position located at other than a taxiway/runway~~,~~ or runway/runway ~~or taxiway/taxiway~~ intersections

Editorial Note.— Make the following change to the text in Figure 5-20:

B2

~~Taxi~~ Runway holding position

5.4.3 Information signs

Note.— See Figure 5-21 for pictorial representations of information signs.

5.4.3.1 The following specifications shall not require the replacement of existing information signs before 1 January 2001. However, any signs installed after 9 November 1995 shall conform to the specifications.

5.4.3.2 An information sign shall be provided where there is an operational need to identify by a sign, a specific location, or routing (direction or destination) information.

5.4.3.3 Information signs shall include: direction signs, location signs, destination signs, runway exit signs, ~~and~~ runway vacated signs and intersection take-off signs.

5.4.3.4 A runway exit sign shall be provided where there is an operational need to identify a runway exit.

5.4.3.5 A runway vacated sign shall be provided where the exit taxiway is not provided with taxiway centre line lights and there is a need to indicate to a pilot leaving a runway the perimeter of the ILS/MLS critical/sensitive area or the lower edge of the inner transitional surface whichever is farther from the runway centre line.

Note.— See 5.3.15 for specifications on colour coding taxi-way centre line lights.

5.4.3.5A **Recommendation.—** *An intersection take-off sign should be provided when there is an operational need to indicate the remaining take-off run available (TORA) for intersection take-offs.*

5.4.3.6 **Recommendation.—** *Where necessary, a destination sign should be provided to indicate the direction to a specific destination on the aerodrome, such as cargo area, general aviation, etc.*

. . . . .

5.4.3.18 Where provided in conjunction with a runway vacated sign, the taxiway location sign shall be positioned outboard of the runway vacated sign.

5.4.3.18A An intersection take-off sign shall be located at the left-hand side of the entry taxiway. The distance between the sign and the centre line of the runway shall be not less than 60 m.

5.4.3.19 A taxiway location sign installed in conjunction with a runway designation sign shall be positioned outboard of the runway designation sign.

5.4.3.20 **Recommendation.—** *A destination sign should not normally be collocated with a location or direction sign.*

5.4.3.21 An information sign other than a location sign shall not be collocated with a mandatory instruction sign.

5.4.3.22 **Recommendation.—** *A direction sign, barricade and/or other appropriate visual aid used to identify a "T" intersection should be located on the opposite side of the intersection facing the taxiway.*

Characteristics

5.4.3.23 An information sign other than a location sign shall consist of an inscription in black on a yellow background.

5.4.3.24 A location sign shall consist of an inscription in yellow on a black background and where it is a stand-alone sign shall have a yellow border.

5.4.3.25 The inscription on a runway exit sign shall consist of the designator of the exit taxiway and an arrow indicating the direction to follow.

5.4.3.26 The inscription on a runway vacated sign shall depict the pattern A taxi-holding position marking as shown in Figure 5-21.

5.4.3.26A The inscription on an intersection take-off sign shall consist of a numerical message indicating the remaining take-off run available in metres plus an arrow, appropriately located and oriented, indicating the direction of the take-off as shown in Figure 5-21.

5.4.3.27 The inscription on a destination sign shall comprise an alpha, alphanumerical or numerical message identifying the destination plus an arrow indicating the direction to proceed as shown in Figure 5-21.

5.4.3.28 The inscription on a direction sign shall comprise an alpha or alphanumerical message identifying the taxiway(s) plus an arrow or arrows appropriately oriented as shown in Figure 5-21.

. . . . .

5.4.3.34 With the exception of runway distance remaining signs, the use of numbers alone on the manoeuvring area shall be reserved for the designation of runways.

Insert new text as follows:

5.4.3A Runway distance remaining signs

Application

5.4.3A.1 **Recommendation.—** *Where there is a requirement to display distance remaining to the pilot, a runway distance remaining sign, either Type A or Type B should be provided. Type A should apply where the metric system is in use and Type B where the imperial system is in use.*

Location

5.4.3A.2 Runway distance remaining signs shall be located along the left side of the runway as viewed from the most often used direction. However, where it is impracticable, they may be placed along the right side of the runway. The signs shall be located at intervals of 300 m for Type A and at intervals of 1 000 ft for Type B. The distance of the sign from the runway edge shall be as shown in Table 5-5 depending on the size of the sign.

Characteristics

5.4.3A.3 A runway distance remaining sign shall consist of an inscription in white on a black background. A Type A sign shall comprise two numerals separated by a decimal point indicating kilometres remaining and a Type B sign shall comprise one or two numerals indicating thousands of feet remaining.

5.4.3A.4 **Recommendation.—** *The sign size should be in accordance with Table 5-5, and the inscription should be as shown in Figure 5-22A. The numerals of the inscription should be in accordance with Annex 14, Volume I, Appendix 4, Figure 4.2.*

5.4.3A.5 **Recommendation.—** *That the reverse face of the sign displays the distance remaining for the reciprocal runway.*

End of new text

Insert new table:

Table 5-5. Runway distance remaining signs

Sign size	Sign heights			Distance from edge of runway
	Legend	Sign face	Overall height	
1	1 000 mm	1 200 mm	1 500 mm	15 - 23 m
2	650 mm	750 mm	1 000 mm	6 - 11 m

End of new table

5.4.4 VOR aerodrome check-point sign

. . . . .

CHAPTER 7. VISUAL AIDS FOR DENOTING RESTRICTED USE AREAS

. . . . .

7.2 Non-load bearing surfaces

Application

7.2.1 Shoulders for taxiways, holding bays and aprons and other non-load bearing surfaces which cannot readily be distinguished from load-bearing surfaces and which, if used by aircraft, might result in damage to the aircraft shall have the boundary between such areas and the load-bearing surface marked by a taxi side stripe marking.

Note.— The marking of runway sides is specified in 5.2.7.

7.2.1A The edges of the load-bearing surfaces of runway turn pads shall be marked by a taxi side stripe marking.

APPENDIX 1. AERONAUTICAL GROUND LIGHTS AND SURFACE MARKINGS COLOURS

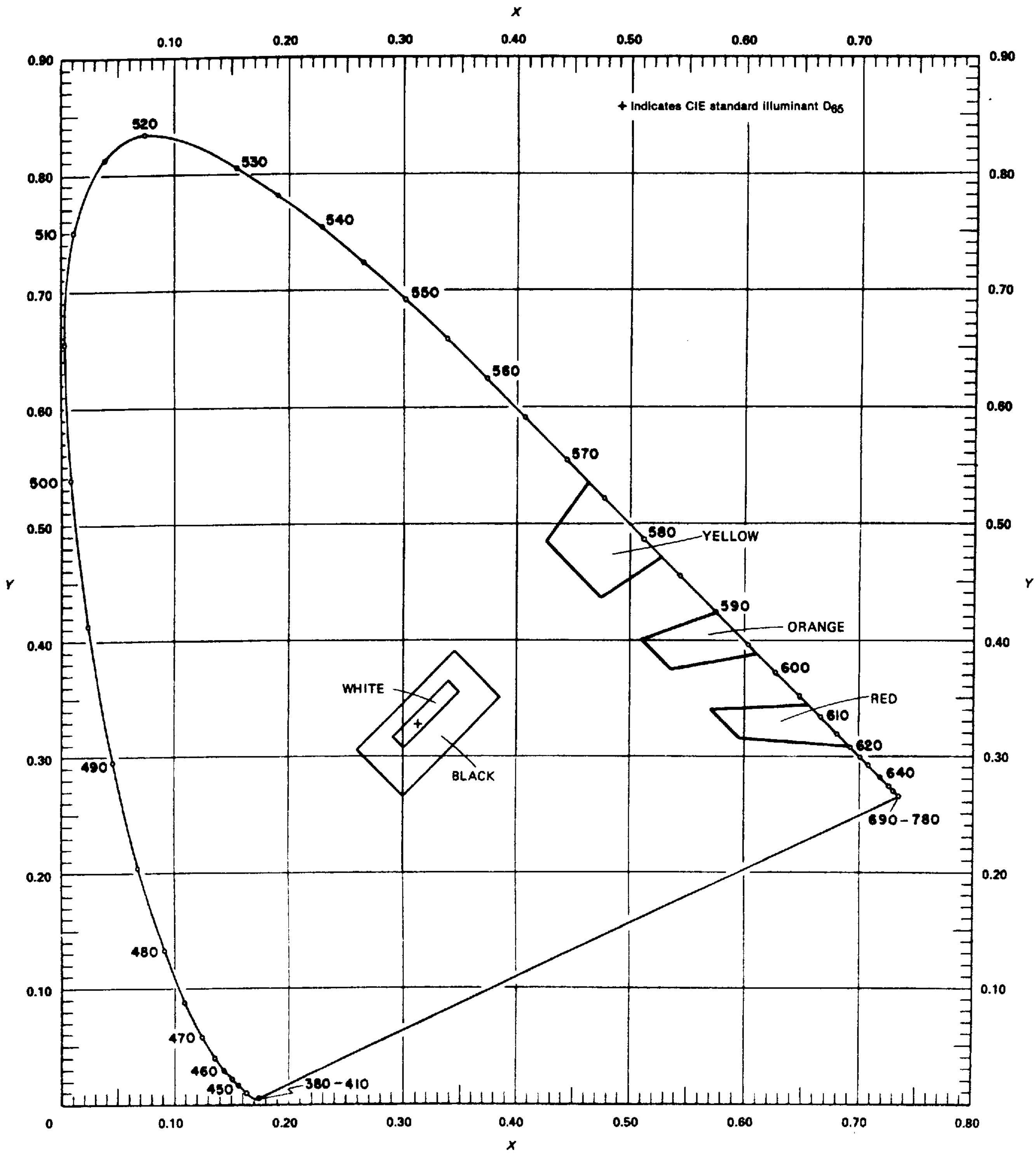


Figure 1.2 Ordinary colours for surface markings and externally illuminated signs and panels

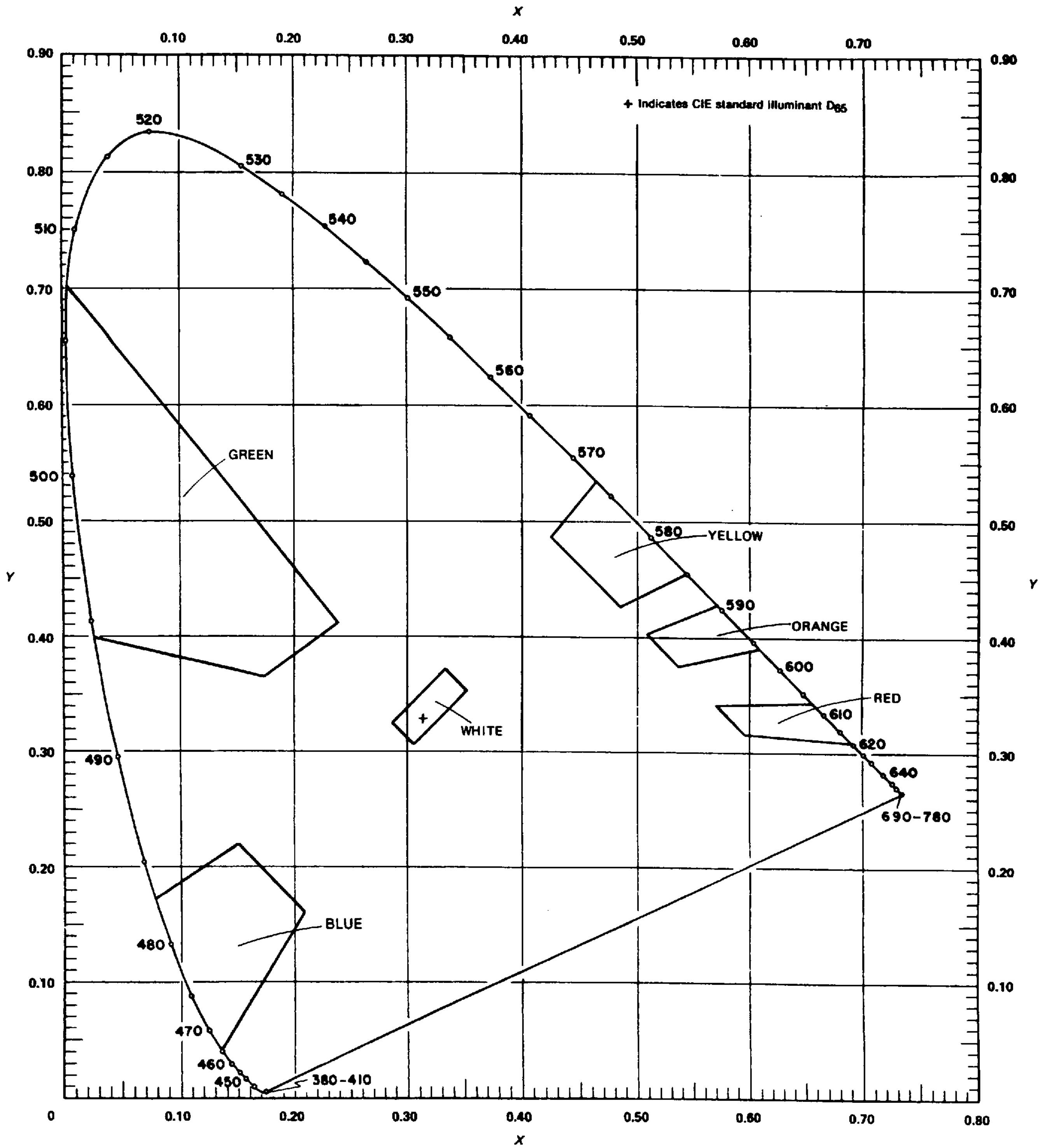
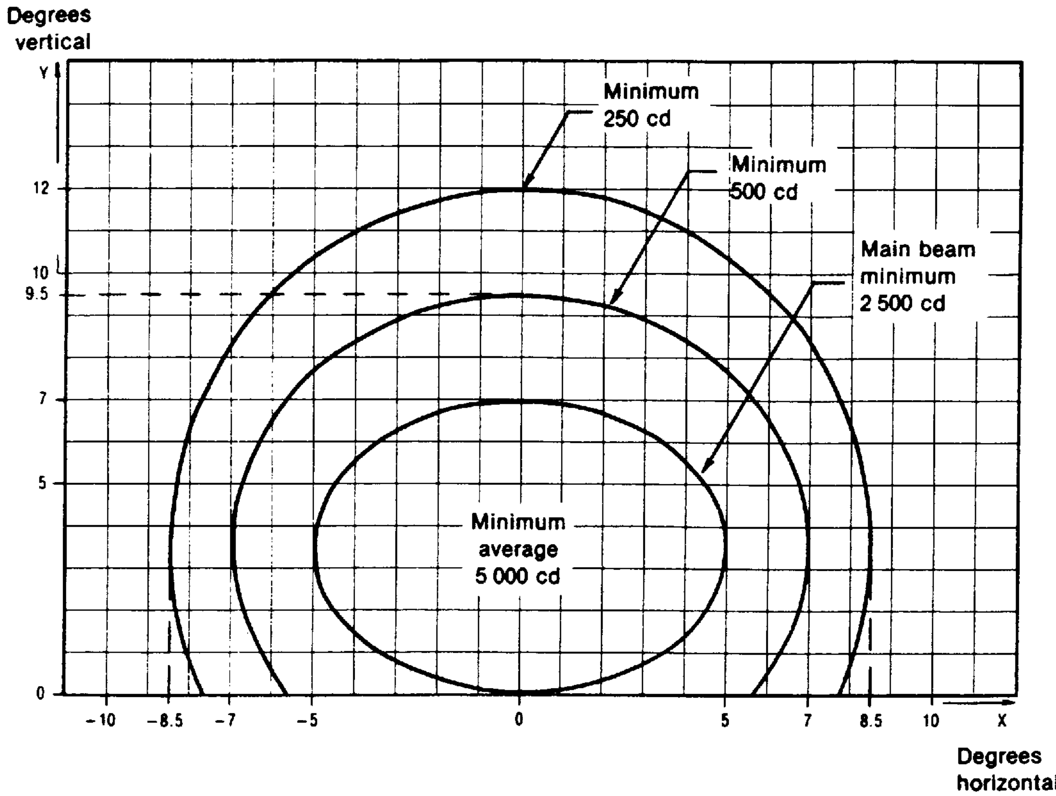


Figure 1.3 Colours of retroreflecting materials for surface markings and retroreflective signs and panels

APPENDIX 2. AERONAUTICAL GROUND LIGHT CHARACTERISTICS



Notes:

1. Curves calculated on formula

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$$

a	5.0	7.0	8.5
b	3.5	6.0	8.5

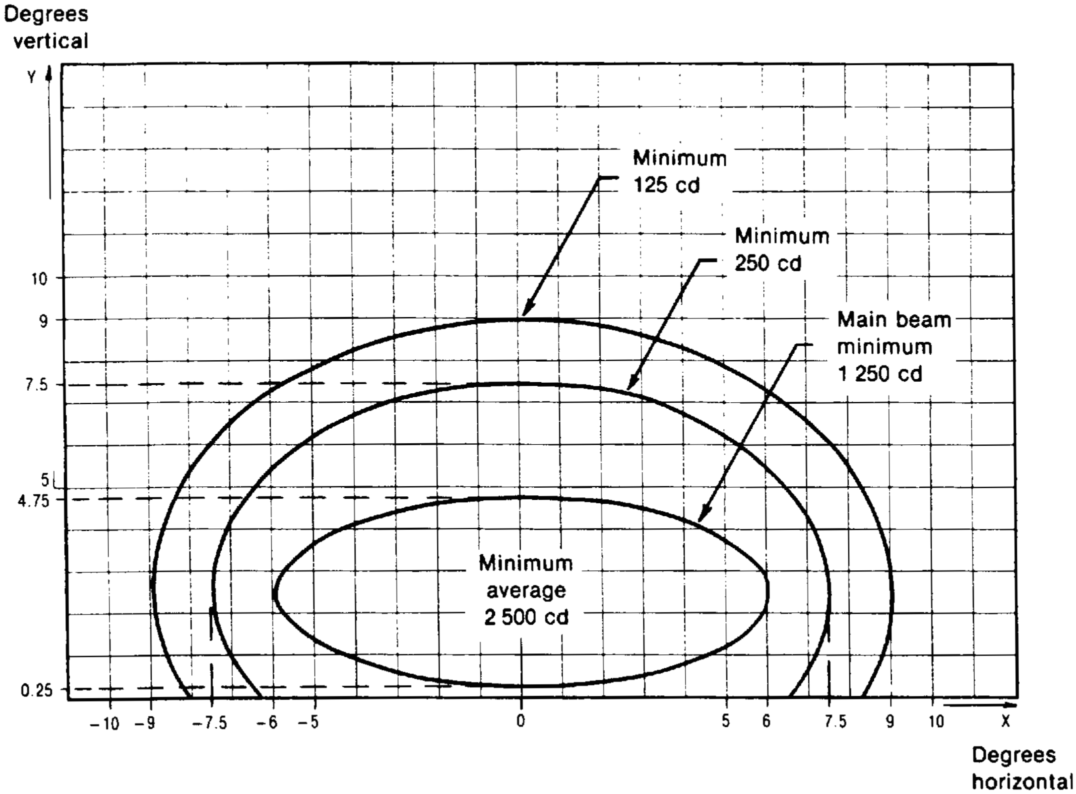
2. For red light multiply values by 0.15

3. For yellow light, multiply values by 0.40

~~3.~~4. See collective notes for Figures 2.1 to 2.12.

Figure 2.6 Isocandela diagram for runway centre line light with 30 m longitudinal spacing (white light), land and hold short alert bar light (white light) and rapid exit taxiway indicator light (yellow light)

. . . . .



Notes:

1. Curves calculated on formula

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$$

a	6.0	7.5	9.0
b	2.25	5.0	6.5

2. See collective notes for Figures 2.1 to 2.12.

Figure 2.9 Isocandela diagram for runway end light (red light) and land and hold short position bar light (red light)

APPENDIX 3. MANDATORY INSTRUCTION AND INFORMATION MARKINGS

Note 1.— See Chapter 5, Sections 5.2.14A and 5.2.15 for specifications on the application, location and characteristics of mandatory instruction and information markings.

Note 2.— This appendix details the form and proportions of the letters, numbers and symbols of mandatory instruction and information markings on a 20 cm grid.

APPENDIX 4. REQUIREMENTS CONCERNING DESIGN OF TAXIING GUIDANCE SIGNS

Note.— See Chapter 5, Section 5.4 for specifications on the application, location and characteristics of signs.

1. Inscription heights shall conform to the following tabulation.

Runway code number	Minimum character height		
	Mandatory instruction sign	Information sign	
		Runway exit and runway vacated signs	Other signs
1 or 2	300 mm	300 mm	200 mm
3 or 4	400 mm	400 mm	300 mm

~~*Note.— Where a taxiway location sign is installed in conjunction with a runway designation sign (see 5.4.3.19), the character size shall be that specified for mandatory instruction signs.*~~

. . . . .

4. Sign luminance ~~(average sign background luminance)~~ shall be as follows:

. . . . .

5. The luminance ratio between red and white elements of a mandatory sign shall be not less than ~~1:5~~ 1:10 and not greater than ~~1:10~~ 1:5.

. . . . .

7. The average value is the arithmetic average of the luminance values measured at all considered grid points.

7A. In order to achieve uniformity of signal, the ratio between luminance values of adjacent grid points shall not exceed 1.5:1. For areas on the sign face where the grid spacing is 7.5 cm, the ratio between luminance values of adjacent grid points shall not exceed 1.25:1. The ratio between the maximum and minimum luminance value over the whole face shall not exceed 5:1.

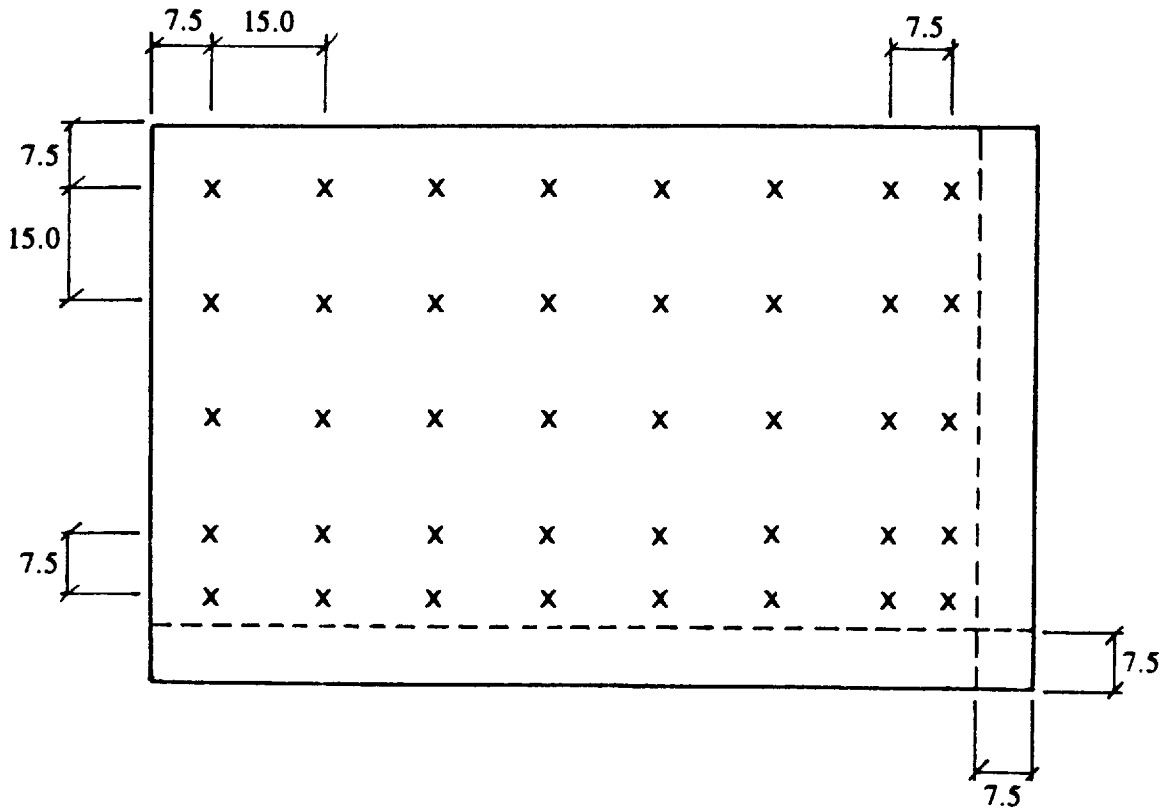
. . . . .

8. The forms of characters, i.e. letters, numbers, arrows and symbols, shall conform to those shown in Figure 4.2. The width of characters and the space between individual characters shall be determined as indicated in Table 4.1.

. . . . .

11A. The colours of signs shall be in accordance with the appropriate specifications in Appendix 1.

Replace existing Figure 4.1 with a new figure as follows:



Note 1.— The average luminance of a sign ~~background~~ is calculated by establishing grid points ~~as shown in the figure~~ on a ~~blank~~ sign face ~~plate (without inscriptions)~~ showing typical inscriptions ~~and a~~ background of the appropriate colour (red for mandatory instruction signs and yellow for direction and destination signs). ~~Luminance values are measured at all grid points within the sign area. The average value of the luminance is the arithmetic mean of all the measured values.~~ as follows:

a) Starting at the top left corner of the sign face, establish a reference grid point at 7.5 cm from the left edge and the top of the sign face.

b) Create a grid of 15 cm spacing horizontally and vertically from the reference grid point. Grid points within 7.5 cm of the edge of the sign should be excluded from the calculations.

c) If the last point in a row/ column of grid points is between 22.5 cm and 15 cm from the edge (but not inclusive), an additional point is to be added 7.5 cm from this point. This is to ensure *that there is not a large gap on the right hand and bottom edges of the signs that does not contain a grid point.*

d) If a grid point falls on the boundary of a character and the background, the grid point shall be slightly shifted to be completely outside the character.

Note 2.— ~~In order to achieve uniformity of signal, luminance values should not exceed a ratio of 1.5:1 between adjacent grid points and 5:1 between maximum and minimum values over the whole face.~~ Additional grid points may be required to ensure that at least five evenly spaced measurements are made within each character.

Note 3.— ~~Grid points within 5 cm of the edge of the sign should be excluded from the calculations.~~ Where two types of signs are included in one unit, a separate grid shall be established for each type.

~~*Note 4.— Further guidance on determining the average luminance of a sign is contained in the* Aerodrome Design Manual, *Part 4 — Visual Aids (Doc 9157).*~~

Figure 4.1 ~~Means of~~Grid points for calculating average luminance of a sign~~ background~~

Insert new Table 4.1 as follows:

Table 4.1 Letter and numeral widths and space between letters or numerals

(a) LETTER TO LETTER CODE NUMBER

Preceding Letter	Following Letter: B, D, E, F, H, I, K, L, M, N, P, R, U	C, G, O, Q, S, X, Z	A, J, T, V, W, Y
	CODE NUMBER		
A	2	2	4
B	1	2	2
C	2	2	3
D	1	2	2
E	2	2	3
F	2	2	3
G	1	2	2
H	1	1	2
I	1	1	2
J	1	1	2
K	2	2	3
L	2	2	4
M	1	1	2
N	1	1	2
O	1	2	2
P	1	2	2
Q	1	2	2
R	1	2	2
S	1	2	2
T	2	2	4
U	1	1	2
V	2	2	4
W	2	2	4
X	2	2	3
Y	2	2	4
Z	2	2	3

(b) NUMERAL TO NUMERAL CODE NUMBER

Preceding Numeral	Following Number: 1, 5	2, 3, 6, 8, 9, 0	4, 7
	CODE NUMBER		
1	1	1	2
2	1	2	2
3	1	2	2
4	2	2	4
5	1	2	2
6	1	2	2
7	2	2	4
8	1	2	2
9	1	2	2
0	1	2	2

(c) SPACE BETWEEN CHARACTERS

CODE NO.	Letter Height (mm) 200	300	400
	SPACE (mm)		
1	48	71	96
2	38	57	76
3	25	38	50
4	13	19	26

(d) WIDTH OF LETTER

Letter	Letter Height (mm) 200	300	400
	WIDTH (mm)		
A	170	255	340
B	137	205	274
C	137	205	274
D	137	205	274
E	124	186	248
F	124	186	248
G	137	205	274
H	137	205	274
I	32	48	64
J	127	190	254
K	140	210	280
L	124	186	248
M	157	236	314
N	137	205	274
O	143	214	286
P	137	205	274
Q	143	214	286
R	137	205	274
S	137	205	274
T	124	186	248
U	137	205	274
V	152	229	304
W	178	267	356
X	137	205	274
Y	171	257	342
Z	137	205	274

(e) WIDTH OF NUMERAL

Numeral	Numeral Height (mm) 200	300	400
	WIDTH (mm)		
1	50	74	98
2	137	205	274
3	137	205	274
4	149	224	298
5	137	205	274
6	137	205	274
7	137	205	274
8	137	205	274
9	137	205	274
0	143	214	286

INSTRUCTIONS

1 To determine the proper SPACE between letters or numerals, obtain the code number from table a or b and enter table c for that code number to the desired letter or numeral height.
2 The space between words or groups of characters forming an abbreviation or symbol should be equal to 0.5 to 0.75 of the height of the characters used except that where an arrow is located with a single character such as 'A →', the space may be reduced to not less than one quarter of the character of the height in order to provide a good visual balance.
3 Where the numeral follows a letter or vice versa use Code 1.
4 Where a hyphen, dot, or diagonal stroke follows a character or vice versa use Code 1.

— — — — — — — —

APPENDIX B

PROPOSED AMENDMENT TO

PROCEDURES FOR AIR NAVIGATION SERVICES (PANS) RULES OF THE AIR AND AIR TRAFFIC SERVICES

NOTES ON THE PRESENTATION OF THE PROPOSED AMENDMENT TO PANS-RAC

The text of the amendment is arranged to show deleted text with a line through it and new text highlighted with grey shading, as shown below:

1.	~~Text to be deleted is shown with a line through it.~~	text to be deleted
2.	New text to be inserted is highlighted with grey shading.	new text to be inserted
3.	~~Text to be deleted is shown with a line through it~~ followed by the replacement text which is highlighted with grey shading.	new text to replace existing text

PART I. DEFINITIONS

Runway. A defined rectangular area on a land aerodrome prepared for the landing and take-off of aircraft.

Runway-holding position. A designated position intended to protect a runway, an obstacle limitation surface, a radio navigation aid sensitive/critical area or the area beyond a land and hold short position at which taxiing aircraft and vehicles shall stop and hold position, unless otherwise authorized by the aerodrome control tower.

Runway visual range. The range over which the pilot of an aircraft on the centre line of a runway can see the runway surface markings or the lights delineating the runway or identifying its centre line.

. . . . .

Surveillance radar. Radar equipment used to determine the position of an aircraft in range and azimuth.

~~***Taxi-holding position.*** A designated position at which taxiing aircraft and vehicles may be required to hold in order to provide adequate clearance from a runway.~~

Taxiing. Movement of an aircraft on the surface of an aerodrome under its own power, excluding take-off and landing.

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PART V. AERODROME CONTROL SERVICE

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CONTROL OF AERODROME TRAFFIC

. . . . .

10. Control of taxiing aircraft

. . . . .

10.2 For the purpose of expediting air traffic, aircraft may be permitted to taxi on the runway-in-use, provided no delay or risk to other aircraft will result.

10.3 Except as provided in 10.3.1 or as prescribed by the appropriate ATS authority, aircraft shall not be held closer to the runway-in-use than at a ~~taxi~~ runway-holding position.

Note.— ~~Taxi~~ Runway-holding position locations in relation to runways are specified in Annex 14, Volume I, Chapter 5.

10.3.1 Aircraft shall not be permitted to hold on the approach end of the runway-in-use whenever another aircraft is effecting a landing, until the landing aircraft has passed the point of intended holding.

Note.— See Figure V-4.

. . . . .

11. Control of other than aircraft traffic on the manoeuvring area

. . . . .

11.3 When an aircraft is landing or taking off, vehicles shall not be permitted to hold closer to the runway-in-use than:

a) at a taxiway/runway intersection — at a ~~taxi~~ runway-holding position; and

b) at a location other than a taxiway/runway intersection — at a distance equal to the separation distance of the ~~taxi~~ runway-holding position.

11.4 The aerodrome control tower shall, prior to a period of application of low visibility procedures, establish a record of vehicles and persons currently on the manoeuvring area and maintain this record during the period of application of these procedures to assist in assuring the safety of operations on that area.

. . . . .

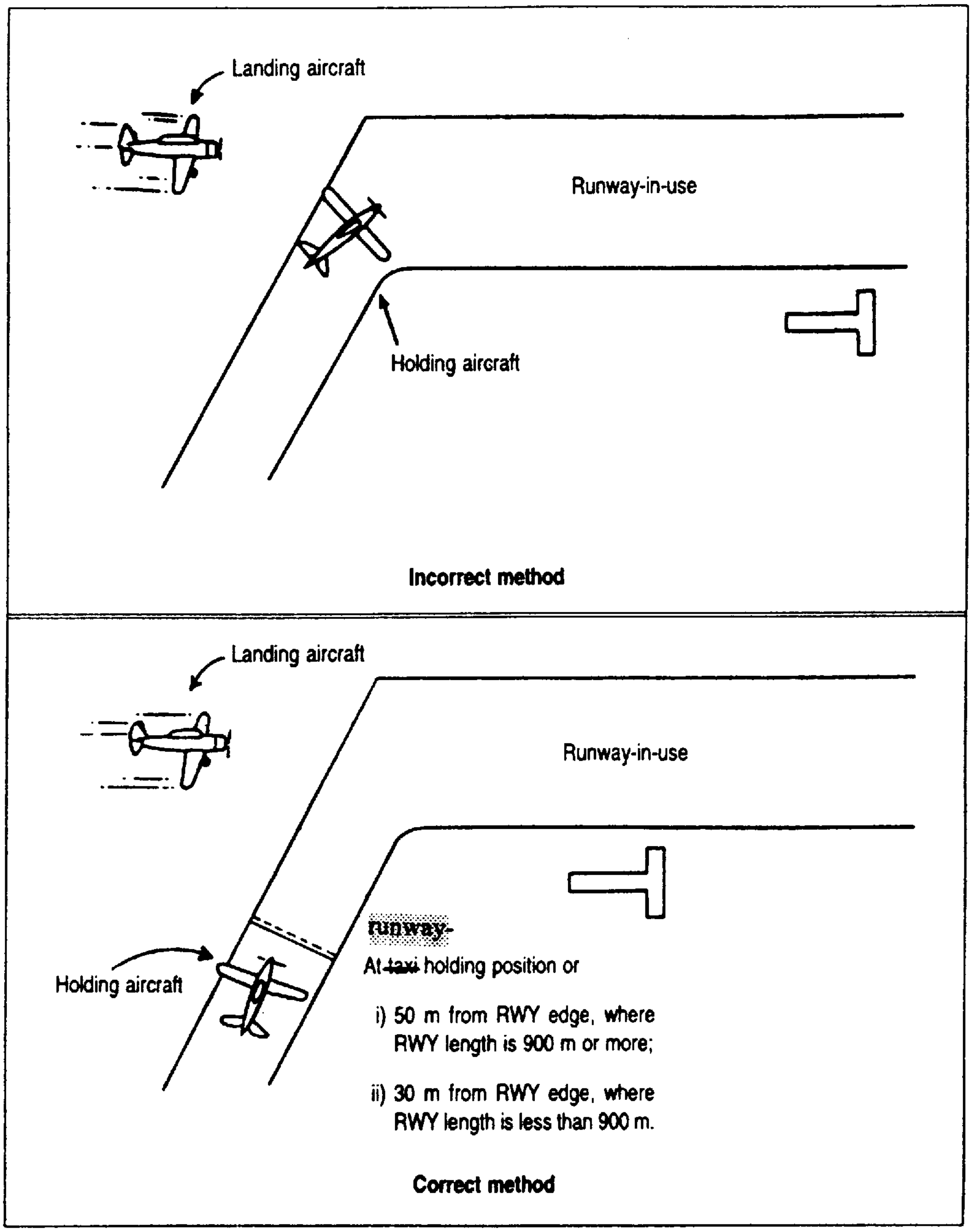

Figure V-4. Method of holding aircraft
(see Section 10)

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APPENDIX C

PROPOSED AMENDMENT TO

PROCEDURES FOR AIR NAVIGATION SERVICES (PANS) AIRCRAFT OPERATIONS

VOLUME II — CONSTRUCTION OF VISUAL AND INSTRUMENT FLIGHT PROCEDURES

PART III. PROCEDURE CONSTRUCTION AND OBSTACLE CLEARANCE CRITERIA FOR INSTRUMENT APPROACH PROCEDURES

NOTES ON THE PRESENTATION OF THE PROPOSED AMENDMENT TO PANS-OPS

The text of the amendment is arranged to show deleted text with a line through it and new text highlighted with grey shading, as shown below:

1.	~~Text to be deleted is shown with a line through it.~~	text to be deleted
2.	New text to be inserted is highlighted with grey shading.	new text to be inserted
3.	~~Text to be deleted is shown with a line through it~~ followed by the replacement text which is highlighted with grey shading.	new text to replace existing text

. . . . .

21.4.8 Obstacle clearance of the precision segment — application of obstacle assessment surface (OAS) criteria

. . . . .

Table III-21-2. Objects which may be ignored in OCA/H calculations

	Maximum height above threshold	*Minimum lateral distance from runway centre line*
GP antenna	17 m (55 ft)	120 m
Aircraft taxiing	22 m (72 ft)	150 m
A/C in holding bay or ~~in taxi~~ at runway holding position at a range between threshold and -250 m	22 m (72 ft)	120 m
A/C in holding bay or ~~in taxi~~ at runway holding position at a range between threshold and -250 m	15 m (50 ft)	75 m

— — — — — — — —

APPENDIX D

PROPOSED AMENDMENT TO

INTERNATIONAL STANDARDS AND RECOMMENDED PRACTICES

AERODROMES

ANNEX 14 TO THE CONVENTION ON INTERNATIONAL CIVIL AVIATION

VOLUME I (AERODROME DESIGN AND OPERATIONS)

NOTES ON THE PRESENTATION OF THE PROPOSED AMENDMENT TO ANNEX 14, VOLUME I

The text of the amendment is arranged to show deleted text with a line through it and new text highlighted with grey shading, as shown below:

1.	~~Text to be deleted is shown with a line through it.~~	text to be deleted
2.	New text to be inserted is highlighted with grey shading.	new text to be inserted
3.	~~Text to be deleted is shown with a line through it~~ followed by the replacement text which is highlighted with grey shading.	new text to replace existing text

CHAPTER 5. VISUAL AIDS FOR NAVIGATION

. . . . .

5.2 Markings

5.2.1 General

. . . . .

5.2.1.3 At an intersection of a runway and taxiway the markings of the runway shall be displayed and the markings of the taxiway interrupted, except that runway side stripe markings may be interrupted.

Note.— See 5.2.8.5 regarding the manner of connecting runway and taxiway centre line markings.

Colour and conspicuity

5.2.1.4 Runway markings shall be white.

Note 1.— It has been found that, on runway surfaces of light colour, the conspicuity of white markings can be improved by outlining them in black.

Note 2.— It is preferable that the risk of uneven friction characteristics on markings be reduced in so far as practicable by the use of a suitable kind of paint.

Note 3.— Markings may consist of solid areas or a series of longitudinal stripes providing an effect equivalent to the solid areas.

5.2.1.5 Taxiway markings and aircraft stand markings shall be yellow.

5.2.1.6 Apron safety lines shall be of a conspicuous colour which shall contrast with that used for aircraft stand markings.

5.2.1.6A **Recommendation.—** *At aerodromes where operations take place at night, pavement markings should be made with reflective materials designed to enhance the visibility of the markings.*

Note.— Guidance on reflective materials is given in the Aerodrome Design Manual, *Part 4.*

Unpaved taxiways

5.2.1.7 **Recommendation.—** *An unpaved taxiway should be provided, so far as practicable, with the markings prescribed for paved taxiways.*

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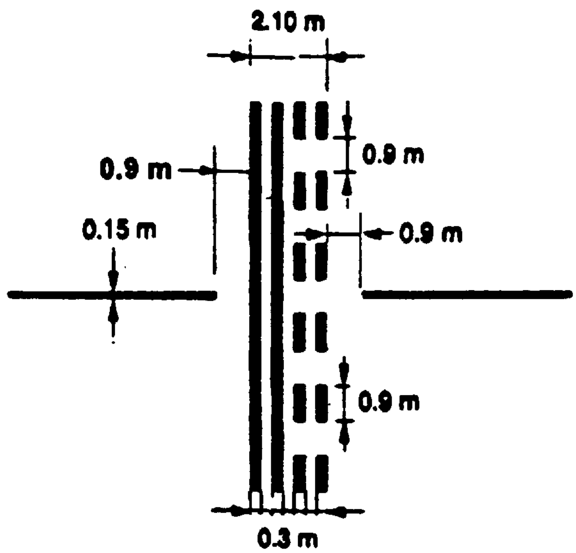
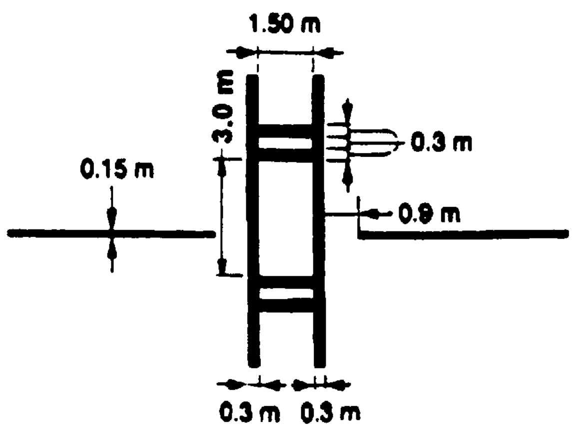
Editorial Note.— The details of the runway-holding position marking in Figure 5-6 shall be replaced by the following figures.

Pattern A



Pattern B



5.3 Lights

. . . . .

5.3.15 Taxiway centre line lights

Application

5.3.15.1 Taxiway centre line lights shall be provided on an exit taxiway, taxiway and apron intended for use in runway visual range conditions less than a value of 350 m, in such a manner as to provide continuous guidance from the runway centre line to the point on the apron where aircraft commence manoeuvring for parking, except that these lights need not be provided where there is a low volume of traffic and taxiway edge lights and centre line marking provide adequate guidance.

5.3.15.2 **Recommendation.—** *Taxiway centre line lights should be provided on a taxiway intended for use at night in runway visual range conditions of 350 m or greater, and particularly on complex taxiway intersections and exit taxiways, except that these lights need not be provided where there is a low volume of traffic and taxiway edge lights and centre line marking provide adequate guidance.*

Note.— Where there may be a need to delineate the edges of a taxiway, e.g. on a rapid exit taxiway, narrow taxiway or in snow conditions, this may be done with taxiway edge lights or markers.

5.3.15.2A Taxiway centre line lights shall be provided on an exit taxiway, taxiway and apron in all visibility conditions where specified as components of an advanced surface movement guidance and control system in such a manner as to provide continuous guidance from the runway centre line to the point on the apron where aircraft commence manoeuvring for parking.

5.3.15.3 Taxiway centre line lights shall be provided on a runway forming part of a standard taxi-route and intended for taxiing in runway visual range conditions less than a value of 350 m, except that these lights need not be provided where there is a low volume of traffic and taxiway edge lights and centre line marking provide adequate guidance.

Note.— See 8.2.3 for provisions concerning the interlocking of runway and taxiway lighting systems.

5.3.15.3A Taxiway centre line lights shall be provided in all visibility conditions on a runway forming part of a standard taxi-route where specified as components of an advanced surface movement guidance and control.

. . . . .

Characteristics

. . . . .

5.3.15.6 Taxiway centre line lights shall be in accordance with the specifications of:

a) Appendix 2, Figure 2.13, 2.14 or 2.15 for taxiways intended for use in runway visual range conditions of less than a value of 350 m; and

b) Appendix 2, Figure 2.16 or 2.17 for other taxiways.

5.3.15.6A Where higher intensities are required for taxiways intended for use in an advanced surface movement guidance and control system, taxiway centre line lights shall be in accordance with the specifications of Appendix 2, Figure 2.12A, 2.12B or 2.12C.

Note.— Higher intensities may be required to maintain ground movement at a certain speed in low visibilities or in bright daytime conditions.

. . . . .

5.3.17 Stop bars

Application

Note.— The provision of stop bars requires their control either manually or automatically by air traffic services.

. . . . .

5.3.17.11 ~~**Recommendation.— *The intensity in red light and beam spreads of stop bar lights should be in accordance with the specifications in Appendix 2, Figures 2.13 through 2.17, as appropriate.***~~ The intensity in red light and beam spreads of stop bar lights shall be in accordance with the specifications in Appendix 2, Figures 2.13 through 2.17, as appropriate.

. . . . .

Note 2.— Care is required in the design of the electrical system to ensure that all of the lights of a stop bar will not fail at the same time. Guidance on this issue is given in the Aerodrome Design Manual, *Part 5.*

5.3.17.12A Where higher intensities are required for stop bars intended for use in an advanced surface movement guidance and control system, stop bar lights shall be in accordance with the specifications of Appendix 2, Figure 2.12A, 2.12B or 2.12C.

Note.— Higher intensities may be required to maintain ground movement at a certain speed in low visibilities or in bright daytime conditions.

5.3.17.12B Where a wide beam fixture is required, stop bar lights shall be in accordance with the specifications of Appendix 2, Figure 2.12A or 2.12C.

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5.3.19 Runway guard lights

. . . . .

Characteristics

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5.3.19.9 **Recommendation.—** *The ~~effective~~ intensity in yellow light and beam spreads of lights of Configuration A should be in accordance with the specifications in ~~Appendix 2, Figure 2.21.~~:*

a) Appendix 2, Figure 2.20A if the runway guard lights are intended to be used during the day or if they are specified as a component of an advanced surface movement guidance and control system where higher light intensities are required; or

b) Appendix 2, Figure 2.21, if otherwise.

5.3.19.10 **Recommendation.—** *The intensity in yellow light and beam spreads of lights of Configuration B should be in accordance with the specifications in ~~Appendix 2, Figure 2.13.~~:*

a) Appendix 2, Figure 2.12D if the runway guard lights are intended to be used during the day or if they are specified as a component of an advanced surface movement guidance and control system where higher light intensities are required; or

b) Appendix 2, Figure 2.13, if otherwise.

5.3.19.11 The lights in each unit of Configuration A shall be illuminated alternately.

5.3.19.11A **Recommendation.—** *Where there is a need to enhance the contrast between the on and off state of each lamp, a visor of sufficient size to prevent sunlight from entering the lens without interfering with the function of the fixture should be located above each lamp.*

Note.— Some other device or design, e.g. specially designed optics, may be used in lieu of the visor.

5.3.19.12 For Configuration B, adjacent lights shall be alternately illuminated and alternative lights shall be illuminated in unison.

5.3.19.13 The lights shall be illuminated between 30 and 60 cycles per minute and the light suppression and illumination periods shall be equal and opposite in each light.

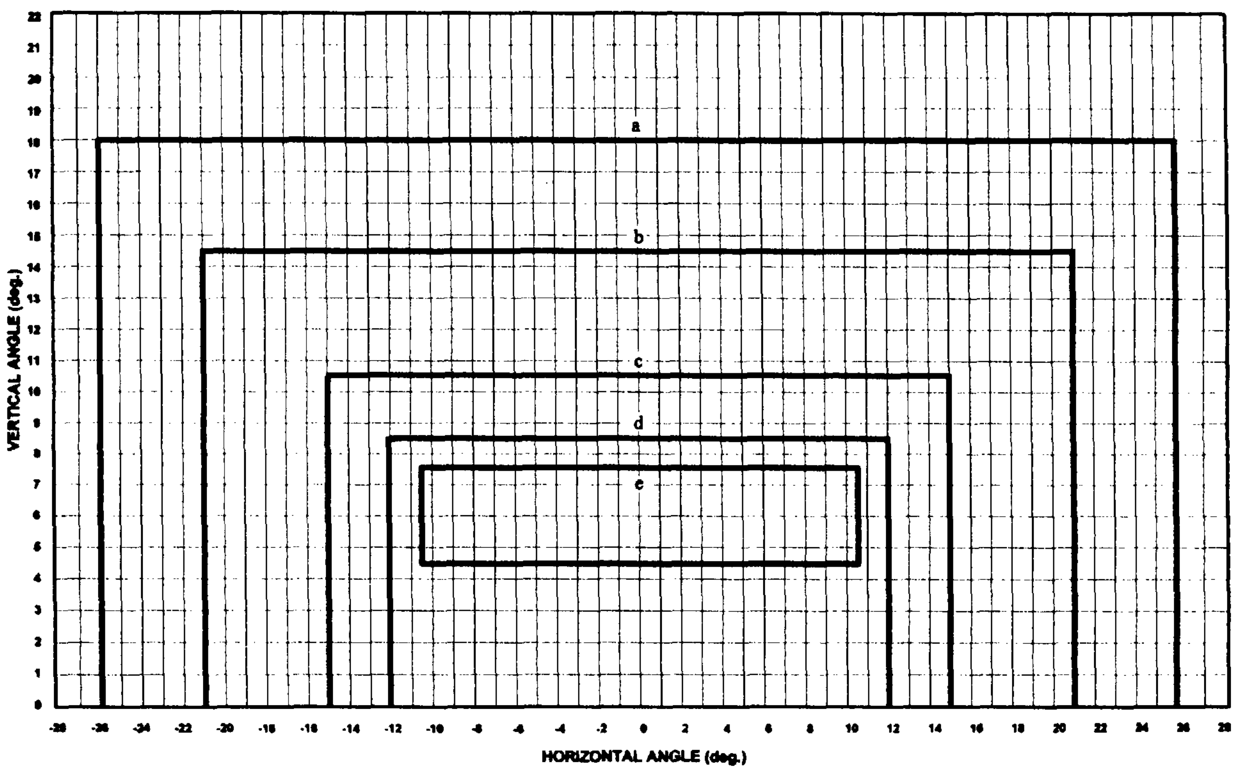
Note.— The optimum flash rate is dependent on the rise and fall times of the lamps used. Elevated runway guard lights installed on 6.6A circuits have been found to look best when operated at 45 to 50 flashes per minute per lamp. In-pavement runway guard lights installed on 6.6A circuits have been found to look best when operated at 30 to 32 flashes per minute per lamp.

. . . . .

APPENDX 2. AERONAUTICAL GROUND LIGHT CHARACTERISTICS

. . . . .

Insert new Figures 2.12A, 2.12B, 2.12C and 2.12D as follows:

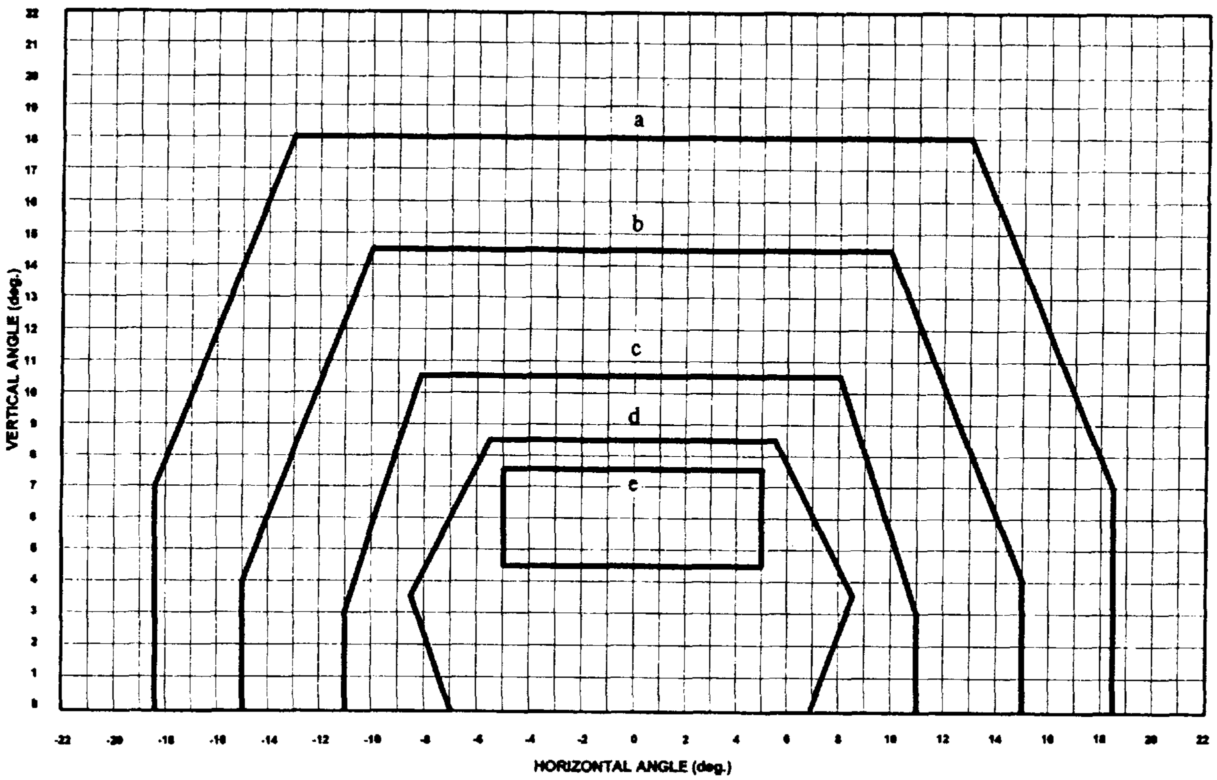


CURVE	a	b	c	d	e
INTENSITY (cd)	8	20	100	450	1800

Notes: 1. These beam coverages allow for displacement of the cockpit from the center line up to distances of the order of 12 m and are intended for use before and after curves.

2. See collective notes for Figures 2.12A to 2.18

Figure 2.12A. Isocandela diagram for high-intensity taxiway centre line (15 m spacing) and stop bar lights in straight sections intended for use in an advanced surface movement guidance and control system where higher light intensities are required and where large offsets can occur

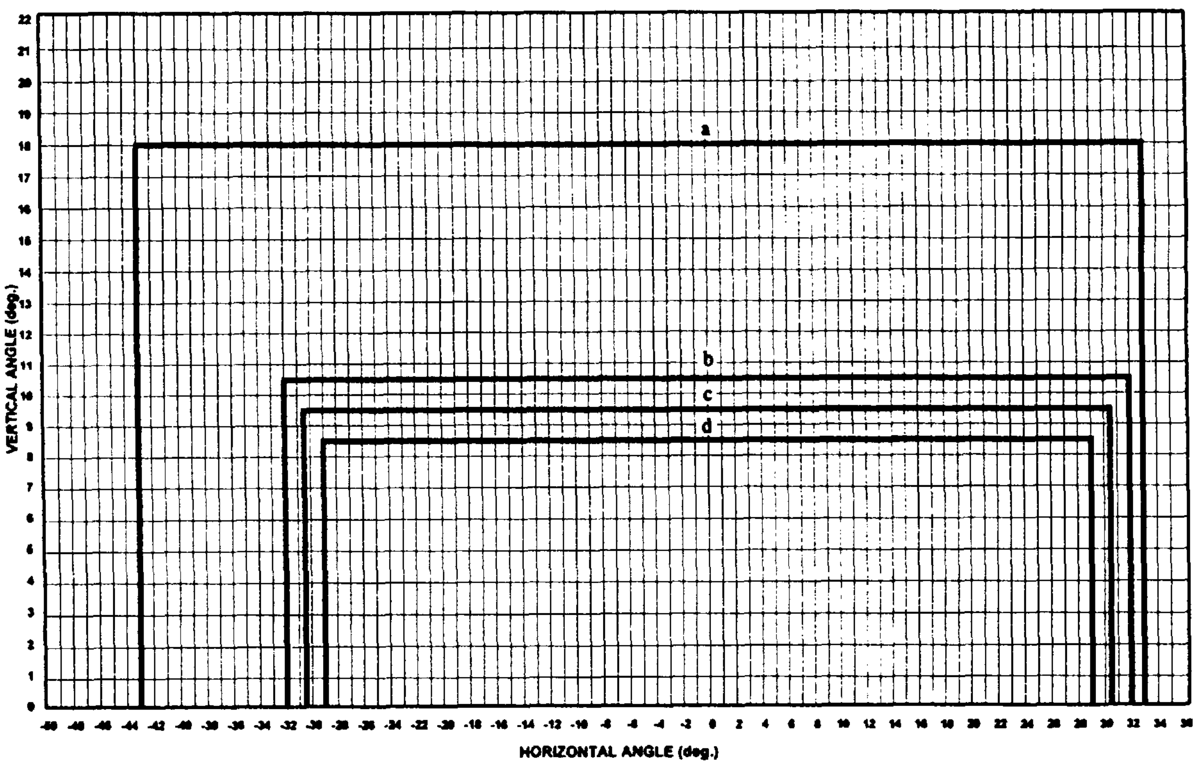


Curve	a	b	c	d	e
Intensity (cd)	8	20	100	450	1800

Notes: 1. These beam coverages are generally satisfactory and cater for a normal displacement of the cockpit corresponding to the outer main gear wheel on the taxiway edge.

2. See collective notes for Figures 2.12A to 2.18

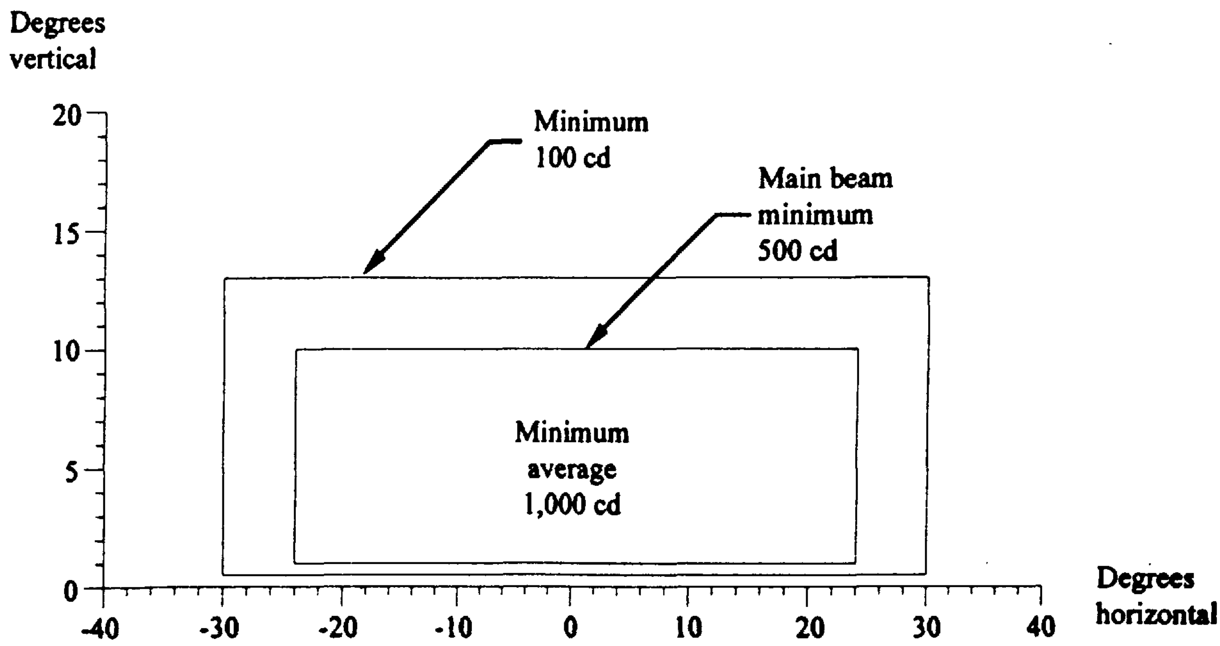
Figure 2.12B. Isocandela diagram for high-intensity taxiway centre line (15 m spacing) and stop bar lights in straight sections intended for use in an advanced surface movement guidance and control system where higher light intensities are required



Curve	a	b	c	d
Intensity (cd)	8	100	200	400

Notes: 1. Lights on curves to be toed-in 17 degrees with respect to the tangent of the curve.
2. See collective notes for Figures 2.12A to 2.18

Figure 2.12C. Isocandela diagram for high-intensity taxiway centre line (7.5 m spacing) and stop bar lights in curved sections intended for use in an advanced surface movement guidance and control system where higher light intensities are required



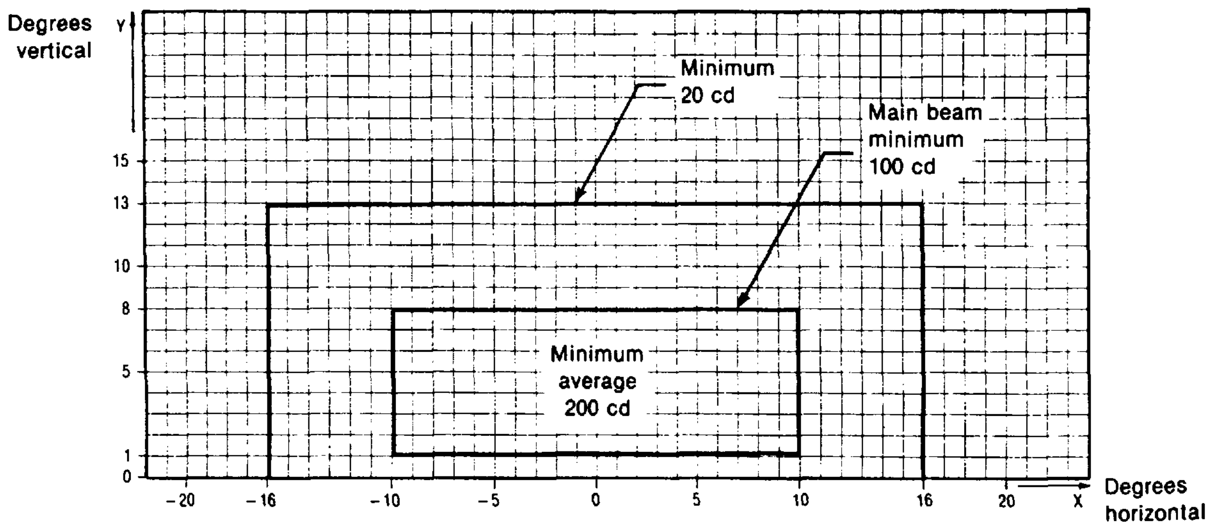
Notes:

1. Although the lights flash in normal operation, the light intensity is specified as if the lights were fixed for incandescent lamps. If strobe lamps are used, the specified intensities are in effective candela.

2. See collective notes for Figures 2.12A to 2.18

Figure 2.12D Isocandela diagram for high-intensity runway guard lights, Configuration B

End of new Figures 2.12A, 2.12B, 2.12C and 2.12D



Notes:

1. These beam coverages allow for displacement of the cockpit from the centre line up to distances of the order of 12 m and are intended for use before and after curves.

2. See collective notes for Figures 2.~~13~~12A to 2.18.

Figure 2.13 Isocandela diagram for taxiway centre line (15 m spacing) and stop bar lights in straight sections intended for use in runway visual range conditions of less than a value of 350 m where large offsets can occur and for low-intensity runway guard lights, Configuration B

. . . . .

Collective notes to Figures ~~2.13~~ 2.12A to 2.18

1. The intensities specified in Figures ~~2.13~~ 2.12A to 2.17 ~~show candela values~~ are in green and yellow light for taxiway centre line lights, yellow light for runway guard lights and red light for stop bar lights.

2. Figures ~~2.13~~ 2.12A to 2.17 show the minimum allowable light intensities. The average intensity of the main beam is calculated by establishing grid points as shown in Figure 2.18 and using the intensity values measured at all grid points located within and on the perimeter of the rectangle representing the main beam. The average value is the arithmetic average of the light intensities measured at all considered grid points.

3. No deviations are acceptable in the main beam or in the innermost beam, as applicable, when the lighting fixture is properly aimed.

4. Horizontal angles are measured with respect to the vertical plane through the taxiway centre line except on curves where they are measured with respect to the tangent to the curve.

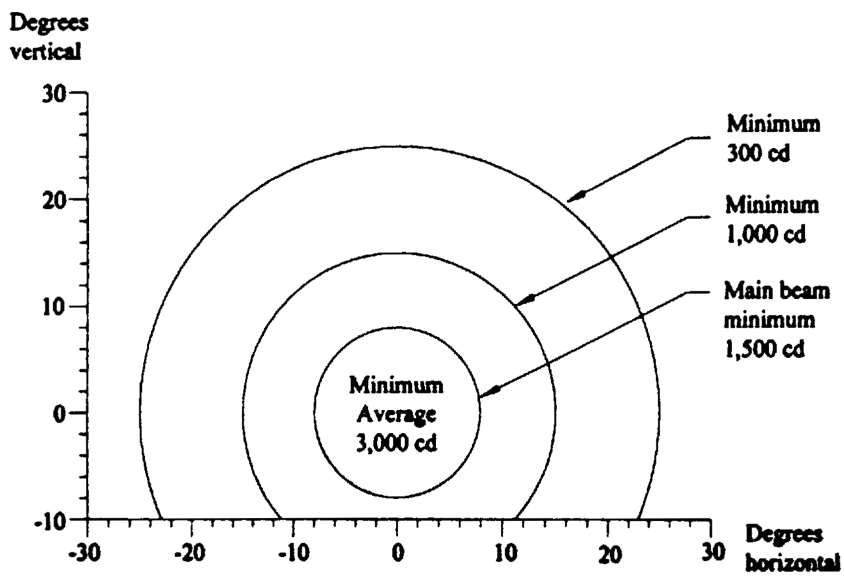
5. Vertical angles are measured from the longitudinal slope of the taxiway surface.

6. The importance of adequate maintenance cannot be over-emphasized. The intensity, either average where applicable or as specified on the corresponding isocandela curves, should never fall to a value less than 50 per cent of the value shown in the figures and it should be the aim of airport authorities to maintain a level of light output close to the specified minimum average intensity.

7. The light unit shall be installed so that the main beam or the innermost beam, as applicable, is aligned within one-half degree of the specified requirement.

. . . . .

Insert new Figure 2.20A as follows:



Notes:

1. Although the lights flash in normal operation, the light intensity is specified as if the lights were fixed for incandescent lamps. If strobe lamps are used, the specified intensities are in effective candela.

2. The intensities specified are in yellow light.

Figure 2.20A Isocandela diagram for each light in high-intensity runway guard lights, Configuration A

End of new Figure 2.20A

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APPENDIX E

PROPOSED AMENDMENT TO

INTERNATIONAL STANDARDS
AND RECOMMENDED PRACTICES

AERODROMES

ANNEX 14
TO THE CONVENTION ON INTERNATIONAL CIVIL AVIATION

VOLUME I
(AERODROME DESIGN AND OPERATIONS)

NOTES ON THE PRESENTATION OF THE PROPOSED AMENDMENT TO ANNEX 14, VOLUME I

The text of the amendment is arranged to show deleted text with a line through it and new text highlighted with grey shading, as shown below:

1.	~~Text to be deleted is shown with a line through it.~~	text to be deleted
2.	New text to be inserted is highlighted with grey shading.	new text to be inserted
3.	~~Text to be deleted is shown with a line through it~~ followed by the replacement text which is highlighted with grey shading.	new text to replace existing text

CHAPTER 5. VISUAL AIDS FOR NAVIGATION

. . . . .

5.2.7 Runway side stripe marking

. . . . .

Insert new text as follows:

5.2.7A Rapid exit taxiway indicator marking

Application

5.2.7A.1 **Recommendation.—** *Rapid exit taxiway indicator markings should be provided on a runway when it is intended to reduce the runway occupancy time of landing aircraft, by enhancing the conspicuity of the approach to a rapid exit taxiway.*

Location

5.2.7A.2 Where rapid exit taxiway indicator markings are provided on a runway they shall be located on the same side of the runway centre line as the rapid exit taxiway for which they provide guidance. The rapid exit taxiway indicator markings shall be as shown in Figure 5-5A.

Characteristics

5.2.7A.3 The rapid exit taxiway indicator markings shall be made up of three sets of markings, as shown in Figure 5-5A. Each marking shall be a single white stripe 5.3 m long and 0.45 m wide. The markings shall be slanted away from the runway centre line such that the nearer end of the nearest stripe is displaced 2.0 m from the runway centre line and the farther end is displaced 3.8 m from the runway centre line. The additional stripes in the first and second sets of markings shall be parallel and spaced at 2 m.

Note.— The markings are slanted away from the runway centre line to indicate the direction of the rapid exit taxiway being approached and to prevent misinterpretation by aircraft landing on the reciprocal runway.

End of new text

Insert new figure as follows:

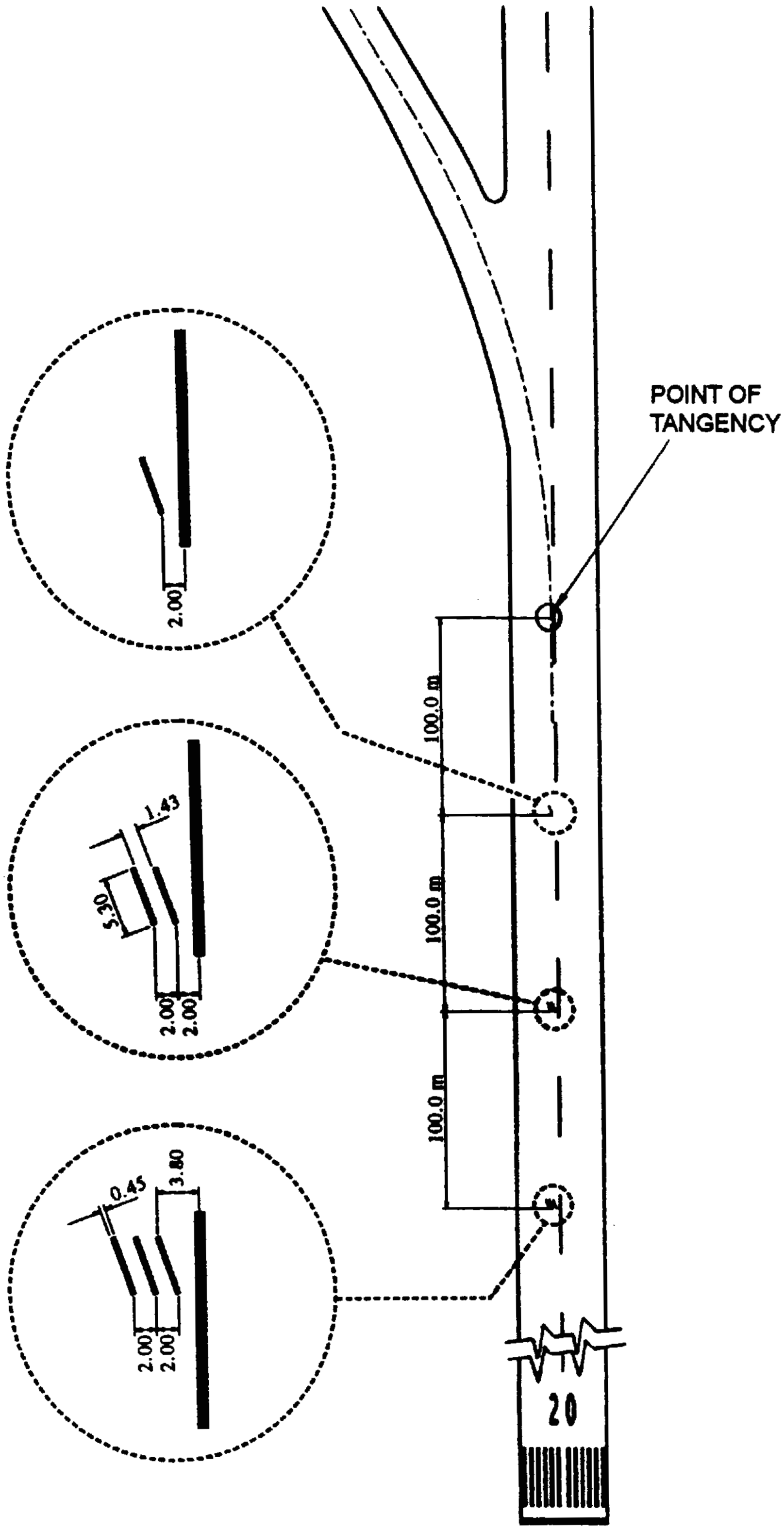


Figure 5-5A. Rapid exit taxiway indicator marking

5.3.13 Runway touchdown zone lights

. . . . .

Insert new text as follows:

5.3.13A Rapid exit taxiway indicator lights

Application

5.3.13A.1 Where rapid exit taxiway indicator markings are provided, rapid exit taxiway indicator lights shall also be provided to give further conspicuity during day and night.

Note.— See 5.2.7A for provisions concerning rapid exit taxiway indicator markings.

Location

5.3.13A.2 A rapid exit taxiway indicator light shall be located at the approach end of each marking in order to maintain the three, two, one coding as the rapid exit taxiway turn off is approached, as shown in Figure 5-5A.

Characteristics

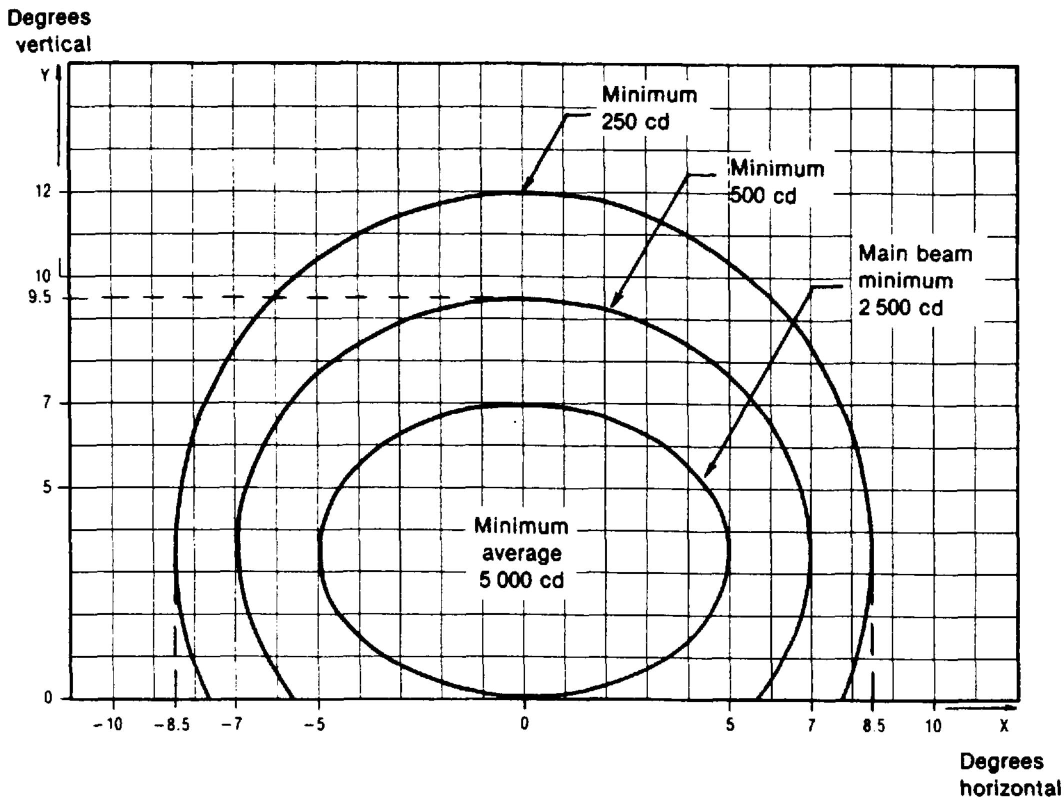
5.3.13A.3 Rapid exit taxiway indicator lights shall be fixed unidirectional lights showing yellow in the direction of approach to the runway.

5.3.13A.4 Rapid exit taxiway indicator lights shall be in accordance with the specifications of Appendix 2, Figure 2.6 or Figure 2.7, as appropriate.

5.3.13A.5 **Recommendation** — *Rapid exit taxiway indicator lights should be supplied with power on a separate circuit to other runway lighting so that they may be used in daylight when other lighting is switched off.*

End of new text

APPENDIX 2. AERONAUTICAL GROUND LIGHT CHARACTERISTICS



Notes.—

1. Curves calculated on formula

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$$

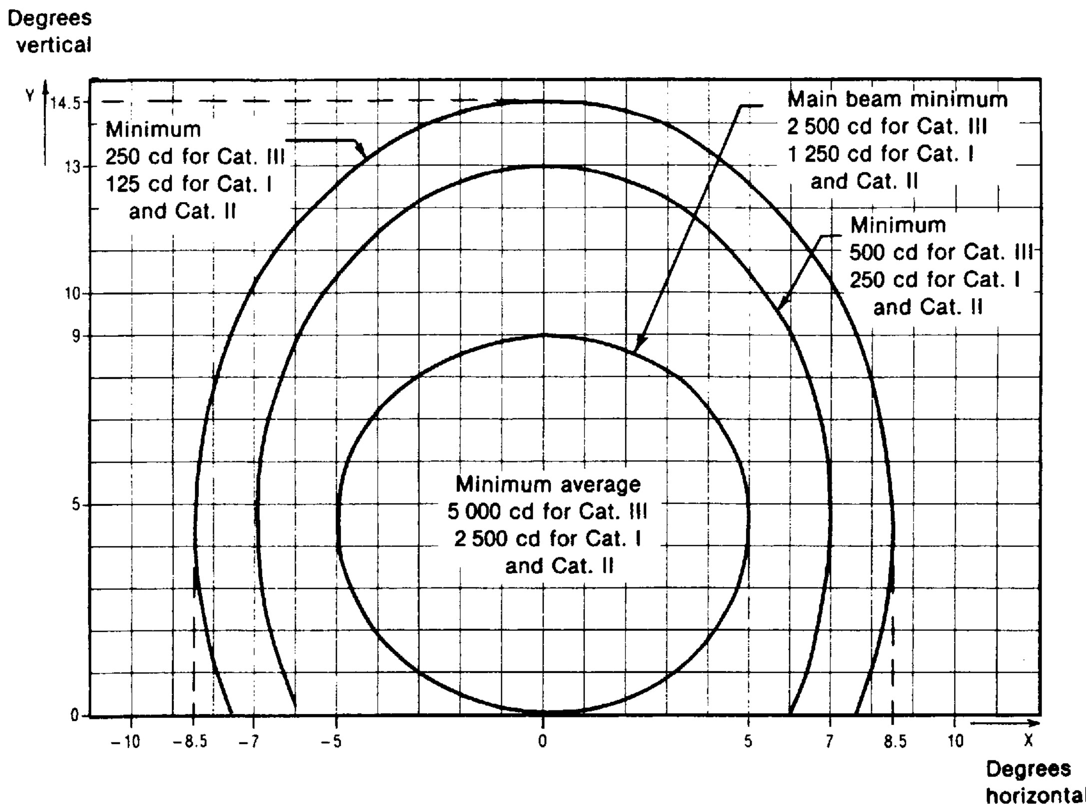
a	5.0	7.0	8.5
b	3.5	6.0	8.5

2. For red light multiply values by 0.15

3. For yellow light, multiply values by 0.40

~~3~~4. See collective notes for Figures 2.1 to 2.12.

Figure 2.6 Isocandela diagram for runway centre line light with 30 m longitudinal spacing (white light), land and hold short alert bar light (white light) and rapid exit taxiway indicator light (yellow light)



Notes.—

1. Curves calculated on formula

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$$

a	5.0	7.0	8.5
b	4.5	8.5	10

2. For red light multiply values by 0.15

3. For yellow light, multiply values by 0.40

~~3.~~ 4. See collective notes for Figures 2.1 to 2.12.

Figure 2.7 Isocandela diagram for runway centre line light with 15 m longitudinal spacing (white light) and rapid exit taxiway indicator light (yellow light)

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APPENDIX F

PROPOSED AMENDMENT TO THE

AERODROME DESIGN MANUAL (ADM)

PART 4 — VISUAL AIDS (DOC 9157)

NOTES ON THE PRESENTATION OF THE PROPOSED AMENDMENT TO THE ADM, PART 4

The text of the amendment is arranged to show deleted text with a line through it and new text highlighted with grey shading, as shown below:

1.	~~Text to be deleted is shown with a line through it.~~	text to be deleted
2.	New text to be inserted is highlighted with grey shading.	new text to be inserted
3.	~~Text to be deleted is shown with a line through it~~ followed by the replacement text which is highlighted with grey shading.	new text to replace existing text

Chapter 2. SURFACE MARKINGS AND MARKERS

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2.3 APRON MARKINGS

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Types of aircraft stand markings

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Reference bars

2.3.15 Examples of reference bars and their functions are:

a) runway turn pad turn bar (indicates the point at which the most critical aircraft must initiate a full turn at the point where the turn bar disappears from pilot view ahead of the aircraft);

b) apron turn bar (indicates the point at which to begin a turn when the pilot position is abeam the turn bar);

c) stop line (indicates the point at which to stop); and

d) alignment bar (assists in aligning the aircraft on the desired angle).

Figure 2-9A shows an example of the use of a).

Figure 2-10 shows an example of the use of b), c) and d).

2.3.16 *Characteristics of reference bars.* Turn bars or stop lines on aprons should be in the order of 6 m in length and not less than 15 cm in width and of the same colour as the guide line, i.e., yellow. ~~They~~ Turn bars on aprons should be located to the left side of and at right angles to the guide lines abeam the pilot seat at the point of turn and stop. The turn bars used in one State include an arrow and the words "FULL TURN" as in Figure 2-5. An alignment bar should be at least in the order of 15 m in length and 15 cm in width and be placed so as to be visible from the pilot seat. The turn bar in a runway turn pad should be located at the end of the taxiway centre line in the turn pad at the point where a full turn is to be initiated. The turn bar should extend at right angles from the taxiway centreline marking in the direction of turn onto the runway. It is intended that the pilot initiate a full turn at the point where the pilot's view of the turn bar disappears from view ahead of the aircraft. A full turn requires maximum steering input by the pilot which results in maximum deflection angle of the nose wheels for most aircraft.

. . . . .

Editorial Note.— The following text is to be inserted in Chapter 11 after paragraph 11.3.11:

Evaluation procedure for signs

11.3.12 To evaluate the physical characteristics of a sign the following procedure should be applied:

a) assess category of operation for which the sign is to be used;

b) measure the sign face height and width, excluding the holder frame where applicable;

c) measure the height of all characters;

d) measure the stroke width of each character, ensure that the stroke width is consistent around the characters, particularly those that contain curved components;

e) measure the width of each character;

f) measure the space around the characters, top, bottom, right and left;

g) measure the border width where applicable;

h) measure the space between words where applicable;

i) where two types of signs are in one unit (e.g. taxiway mandatory and information signs), measure the separation between the signs; and

j) compare the measured dimensions and spacings with the recommendations given in Annex 14, Volume I, Appendix 4.

11.3.13 To evaluate the photometric performance of a sign the following procedure should be applied:

a) the photometric performance of the sign is to be evaluated in a darkened environment;

b) mark out the grid on the sign face as shown in Annex 14, Volume I, Appendix 4, Figure 4.1 (exclude any framework). Ensure that the rows/columns of grid points are correctly aligned parallel to both the top and left edge of the sign face;

c) at a an appropriate range from the sign, measure the luminance and colour co-ordinates at each applicable grid point ensuring that the area used for each individual measurement does not exceed that prescribed by a circle of diameter 3 cm centred on the grid point. For externally lit signs, ensure the measurement is taken from behind the light source;

d) calculate the average luminance level for each colour and compare the values with the minimum values recommended in Annex 14, Volume I, Appendix 4;

e) in order to ensure that uniformity of luminance has been achieved, calculate the ratio between the maximum and minimum luminance values for each colour and compare with the maximum recommended ratio in Annex 14, Volume I, Appendix 4;

f) for a mandatory (red and white) sign, Annex 14, Volume I, Appendix 4 recommends a maximum and minimum ratio between the average red luminance and the average white luminance. Confirm that the measured values are within the recommended range;

g) assess the ratios of adjacent luminance levels in the vertical and horizontal planes and compare with the recommended maximum ratio given in Annex 14, Volume I, Appendix 4 (assess the ratio between adjacent points of the same colour only); and

h) calculate the average of the colour co-ordinates for each colour and confirm that the values are within the boundaries recommended in Annex 14, Volume I, Appendix 1.

Note.— Signs of different lengths may have different photometric performances.

Determining the face width of a sign

11.3.14 The following figures provide guidance on how to determine the face width of a sign:

Item	Width (mm)
½ H	200
2	274
character space	76
7	274
character group space	280
C	274
character space	50
A	340
character space	26
T	248
character group space	280
III	440
½ H	200
Total width	2962

Figure 1. Inscription 27 CAT III, letter height 400 mm

Item	Width (mm)
½ H	150
A	255
character space	57
P	205
character space	71
R	205
character space	57
O	214
character space	71
N	205
character group space	210
→	300
½ H	150
Total width	2150

Figure 2. Inscription APRON →, letter height 300 mm

Note.— The space between character groups or character groups and symbol should be equal to the average width of the used letter height:

letter height (mm)	*average letter width (mm)*
400	*280*
300	*210*
200	*140*

End of new text

Appendix 3. SELECTION, APPLICATION AND REMOVAL OF PAINTS

. . . . .

SELECTION OF RETRO-REFLECTIVE ELEMENT (GLASS BEADS)

Conditions for using ~~retro-~~reflective markings

9. ~~Retro-r~~Reflective aerodrome markings are used to improve performance of the markings at night, especially in conditions when the markings may be wet. Because of the additional costs, some authorities may use ~~retro-~~reflective markings only for those aerodromes which can benefit from the improved performance. Aerodromes which operate only during daylight or are used only by aircraft without landing or taxiing lights would not need to provide reflectorized markings. ~~Retro-~~Reflective markings may not be necessary on runways with operating runway centre line and touchdown zone lights; however, the ~~retro-~~reflective markings may be helpful for night-time operations in clearer visibilities when the centre line and touchdown zone lights are not energized. Tests have shown that the reflectivity of markings may be enhanced by factors in excess of 5 by the inclusion of glass beads.

Specification of glass beads

10. The primary characteristics of retro-reflective beads ~~(glass spheres)~~ to be considered in selection for aerodrome markings are composition, index of refraction, gradation and imperfections. Glass beads ~~spheres~~ which are lead-free, uncoated, with a refractive index of 1.90 or greater, have size gradation between 0.40 and 1.30 mm diameter and have less than 33 per cent imperfections have been found best for aerodrome markings. Glass beads with a refractive index of 1.5, whilst not as efficient as beads with a higher refractive index, are beneficial in increasing the reflectivity of markings. On the other hand, they are also less prone to mechanical damage in some circumstances. Therefore, in such circumstances markings containing glass beads with a refractive index of 1.5 and markings containing glass beads with a refractive index of 1.9 or greater may prove equally efficient after a certain period of usage.

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PART II — REPORT ON AGENDA ITEM 2

Agenda Item 2: Secondary power supply and design

2.1 INTRODUCTION

2.1.1 The purpose of this agenda item was to study Annex 14, Volume I, Chapter 8, Sections 8.1 to 8.3 and Table 8-1 with a view to:

a) including secondary power supply requirements for take-off runways meant for use in runway visual range (RVR) conditions greater than 550 m;

b) including secondary power supply requirements for category I operations over hazardous or precipitous terrain; and

c) developing a definition for the term "1 second switch-over time".

2.1.2 The purpose was also to review the current status of work on the updating of the *Aerodrome Design Manual*, Part 5 — *Electrical Systems* (Doc 9157).

2.1.3 The VAP/11 Meeting (1987) considered that an overall review and updating of the current Annex 14 provisions relating to secondary power supply, circuit design and monitoring was needed to ensure that the specified requirements were appropriate and compatible. These requirements were formulated at different times and had often been found to be unrealistic and difficult to meet. Accordingly, VAP/11 recommended that an appropriate item be added to the VAP work programme. The Air Navigation Commission concurred with this recommendation and the panel established a working group, known as the Working Group on Design and Monitoring of Electrical Systems, to accomplish the task. The task was partly resolved at the VAP/12 Meeting (1991) and the proposed amendments developed at that meeting have since been incorporated into the Second Edition of Annex 14, Volume I.

2.1.4 The task is currently included in work programme Item 3 — Secondary power supply and design. One new issue related to secondary power supply requirements for category I operations over hazardous or precipitous terrain was added to the work programme item after the Commission's final review of the proposals for amendment to Annex 14, Volume I stemming from the recommendations of VAP/12. This was in response to a comment forwarded by the International Federation of Air Line Pilots' Associations (IFALPA) suggesting that, where category I operations were conducted over hazardous or precipitous terrain, switch-over times considerably shorter than those envisaged in Table 8-1 in Annex 14, Volume I would be required.

2.1.5 Whilst progressing the above task, the working group had concluded that the guidance material related to electrical systems included in the *Aerodrome Design Manual*, Part 5 was incomplete and to a certain extent outdated. This was further discussed at the VAP/12 Meeting and, as a result, VAP/12 recommended that the design manual be updated with the assistance of the current membership of the panel at the time and with some degree of urgency. The Commission approved this recommendation and the issue was also added to work programme Item 3. In this context, it should be noted that the panel did not consider it advisable to have the manual reviewed and updated by a consultant. It felt that any material meant for worldwide use should be written by a group of experts rather than by a single individual.

2.1.6 The Working Group on Design and Monitoring of Electrical Systems met six times after VAP/12 and the results of its work, which included proposals for amendment to Annex 14, Volume I as well as updated guidance material for inclusion in the *Aerodrome Design Manual*, Part 5, were presented at the meeting. Furthermore, the rapporteur of the working group provided a progress report on the overall updating of the design manual for review by the meeting.

2.2 PROPOSALS FOR AMENDMENT OF ANNEX 14, VOLUME I

2.2.1 The meeting reviewed and refined the above-mentioned amendment proposals and the results are reflected in Appendix A to the report on this agenda item. The following paragraphs detail the more significant issues discussed and conclusions reached.

2.2.2 Secondary power supply requirements for take-off runways meant for use in runway visual range (RVR) conditions greater than 550 m

2.2.2.1 There is no requirement specified for secondary power supply for runways meant for take-off in runway visual range (RVR) conditions greater than 550 m in the current edition of Annex 14, Volume I.

2.2.2.2 At the VAP/12 Meeting, the working group had proposed that the switch-over time requirements specified in Annex 14, Volume I, Table 8-1 for take-off runways used in RVRs less than 400 m be extended to cover take-off runways used in RVRs less than 1 200 m. VAP/12, however, considered that this proposal was excessive and that the envisaged course would unnecessarily place a financial burden on States. Furthermore, the proposal was not compatible with the switch-over time requirements specified for landing runways used in similar RVR conditions. Instead, VAP/12 agreed to extend the applicability of the switch-over times specified for take-off runways intended for use in RVRs below 400 m to those meant for use in RVRs below 800 m only. As regards switch-over times for take-off runways meant for use in RVRs greater than 800 m, VAP/12 concluded that this issue would require further studies.

2.2.2.3 At its fourth meeting, the working group revisited the issue of switch-over time requirements for take-off runways meant for use in RVRs greater than 800 m and arrived at the following conclusions:

a) take-off in RVRs greater than 800 m was not more demanding than landing;

b) centre line lighting was not required;

c) a low intensity system was adequate for night take-off;

d) lighting was not essential for daylight operations;

e) secondary power was not required; and

f) runways used for take-off only in RVRs greater than 800 m were not operationally significant.

2.2.2.4 Accordingly, the working group had agreed that there was no need to specify secondary power supply requirements for take-off runways meant for use in RVRs greater than 800 m.

2.2.2.5 At the time of VAP/12, Annex 14, Volume I defined a precision approach runway, category I as being intended for operations down to an RVR of the order of 800 m. However, in November 1994, Annex 6 introduced definitions for the classification of instrument approach and landing operations which *inter alia* included an RVR minimum of 550 m for category I approaches. In light of this change, prior to incorporation in the Second Edition of Annex 14, Volume I, the amendment to Table 8-1 proposed by VAP/12 was adjusted by the Secretariat to include secondary power requirements for take-off runways meant for use in RVRs less than 550 m only. Accordingly, the working group had concluded that the issue of switch-over times for take-off runways meant for use in RVRs greater than 550 m but less than 800 m needed to be addressed.

2.2.2.6 The discussion of the issue revealed a division of opinion among the members of the working group. Several members considered that take-off in RVRs greater than 550 m would be no more demanding than landing and that no further amendment to Table 8-1 was required. Other members, however, considered that there was a difference between 15 seconds without lights in an RVR of 550 m compared to 15 seconds without lights in an RVR of 800 m particularly during ground roll at take-off during night-time. It was believed that, at night in runway visual range conditions less than 800 m, there was a significant possibility that pilots during roll-out and take-off might extinguish the aircraft external lighting because of the back scatter caused by reflections from water droplets suspended in the atmosphere. In such circumstances, a 15-second loss of external visual guidance would not be acceptable. In this context, the working group had been reminded that the required visual cues did not change when the boundaries between category I and category II operations were revised.

2.2.2.7 The meeting revisited the issue. The meeting agreed that the required visual cues did not change when the RVR minimum for category I approaches had been redefined and that, therefore, it would not necessarily be correct to revise all related RVR values from 800 m to 550 m. The meeting reviewed the operational situation during ground roll at take-off at night in runway visual range conditions less than 800 m highlighted by the working group and agreed that it would be appropriate to extend the applicability of the switch-over times specified for take-off runways intended for use in RVRs below 550 m to those meant for use in RVRs below 800 m. The meeting further agreed that a consequential amendment to Annex 14, Volume I, paragraph 8.1.8 would be required.

2.2.3 Secondary power supply requirements for category I operations over hazardous or precipitous terrain

2.2.3.1 The issue related to secondary power supply requirements for category I operations over hazardous or precipitous terrain had been raised by IFALPA (paragraph 2.1.4 above refers). The rationale behind the IFALPA position was that, in areas of hazardous or precipitous terrain, pilots would prefer to conduct a landing rather than a missed approach procedure and, therefore, a higher level of availability of essential visual aids would be desirable.

2.2.3.2 Based on a review of the lighting aids requiring secondary power listed in Table 8-1, the working group had agreed that the primary aids needed for landings in runway visual range conditions greater than a value of 550 m would be visual approach slope indicators, runway threshold lights and runway edge lights. It had also agreed that, for a runway located in an area of hazardous or precipitous terrain, these facilities should be supplied with secondary power and that the maximum switch-over time should be 1 second.

2.2.3.3 The working group had further suggested that the requirements identified in paragraph 2.2.3.2 above would be equally valid for non-precision approach and non-instrument runways.

2.2.3.4 The meeting endorsed the conclusions of the working group. The meeting also endorsed the related proposal developed by the working group for amendment to Annex 14, Volume I.

2.2.4 **Definition of the term "switch-over time"**

2.2.4.1 Prior to the VAP/12 Meeting, the working group saw the need to include the definition of the term "switch-over time" in an appropriate document. This was considered particularly important to verify if the 1 second switch-over time specified in Table 8-1 was met. Accordingly, the working group had developed the following definition:

> "The maximum switch-over time is the time required for the light output to fall from 80 per cent and recover to 80 per cent during a power supply change over."

2.2.4.2 When VAP/12 reviewed the proposal, it was concluded that it would be inappropriate to apply this definition, as the switch-over time measured on the lines envisaged in the definition would be in the order of 1.5 to 2 seconds as opposed to the 1 second specified in Table 8-1. The issue proved highly controversial and VAP/12 could not define the term.

2.2.4.3 Subsequent studies conducted by the working group had verified that a significant number of existing installations, for which the requirement of maximum 1 second switch-over time was specified, would not meet the specifications if the new definition was adopted. Tests performed in different States had shown that interruptions in the light output would be in the order of 1.5 to 3 seconds.

2.2.4.4 Further trials were conducted in Canada and France with the view to determining the duration of the visual interruption in light output as opposed to the duration of the interruption in actual light output. The results of these trials indicated that generally the duration of the visual interruption in light output was considerably less than the duration of the interruption in actual light output. The results also indicated that it would be appropriate to measure the duration of the interruption in actual light output as the time required for the light output to fall from 50 per cent and recover to 50 per cent. This was because, even when measured at this lower value, the interruption in actual light output of 1 second would result in a duration of the visual interruption in light output that would be acceptable for category II/III operations.

2.2.4.5 In light of the foregoing, the working group had concluded:

a) that the specified maximum allowable interruption in service at automatic switch-over to secondary power supply in the case of failure of the normal power source should be based on light output rather than restoration of power supply to specific circuits in order to more adequately reflect the interruption in service to a pilot;

b) that the definition of the term "switch-over time" should take into account that generally the duration of the visual interruption in light output was considerably less than the duration of the interruption in actual light output;

c) that the duration of the interruption in actual light output should be measured as the time required for the light output to fall from 50 per cent and recover to 50 per cent; and

d) that it would be appropriate to retain the Annex 14, Volume I requirements of "1 second switch-over time" as listed in Table 8-1.

2.2.4.6 Consequently, the working group had developed the following revised definition for the term "switch-over time":

> "Switch-over time is the time required for the actual light intensity measured in a given direction to fall from 50 per cent and recover to 50 per cent during a power supply change-over."

2.2.4.7 The meeting reviewed the proposed new definition. There was some concern that, for constant current series circuits, lighting systems operating at low-level brilliancy would not be able to meet the requirements of the proposed new definition. However, it was pointed out that in such cases a somewhat longer switch-over time would not be critical. The most critical case would be in low visibility conditions with lighting systems operating at high-level brilliancy. The meeting, therefore, agreed that measurements of switch-over times should be made when the lighting system concerned was operating at intensity settings of 25 per cent or above.

2.2.4.8 Other issues that generated some discussions were the need to include the phrase "in a given direction" in the definition and the perceived complexity of performing the required measurements in the field. In this context, it was recalled that the working group had concluded that the allowable interruption in service should be based on measuring the light output rather than electrical measurements. Furthermore, several members indicated that there were no particular problems associated with conducting in-field measurements of light intensity.

2.2.4.9 It was also suggested that the term "switch-over time" indicated electrical measurements rather than measurement of light output and that a change of term might be warranted. As a proposal, the term "light recovery time" was mentioned. The meeting, however, considered that the term "switch-over time" was well established within the industry and the proposal was, therefore, not supported.

2.2.4.10 In light of the above, the meeting agreed to modify the new definition proposed by the working group as follows:

> "Switch-over time is the time required for the actual intensity of a light measured in a given direction to fall from 50 per cent and recover to 50 per cent during a power supply change-over, when the light is being operated at intensities of 25 per cent or above."

2.2.4.11 The meeting also agreed that the definition should be included in Annex 14, Volume I, Chapter 1 and that a reference to this definition should be incorporated into Annex 14, Volume I, paragraph 8.1.3.

2.2.4.12 Finally, the meeting discussed the need for the introduction of a protection date for lighting systems that did not meet the 1 second switch-over time requirement according to the new definition. The meeting concluded that lighting installations on very many airports worldwide would not meet the proposed new requirement. Furthermore, it was estimated that the equipment included in such lighting installations had a life span of fifteen to twenty years. In view of this, the meeting agreed to recommend that existing lighting systems not meeting the 1 second switch-over time requirement should require replacement by a specified date not exceeding ten years from the date the proposed new definition of the term "switch-over time" would become applicable. Accordingly, the meeting formulated Recommendation 2/2 to the report on this agenda item.

2.2.5 Review of Annex 14, Volume I, Chapter 9

2.2.5.1 The working group had examined Annex 14, Volume I, Chapter 9 on a general basis and had concluded the following:

a) since paragraph 9.4.19 specified when a light unit should be deemed unserviceable, there was no need to retain the definition of light failure included in Annex 14, Volume I, Chapter 1 (the current definition was more of a performance requirement than a definition);

b) the Note preceding paragraph 9.4.19 needed to be amended to clearly indicate that the specifications in the following paragraphs 9.4.19 to 9.4.27 are related to maintenance requirements only as opposed to operational requirements; and

c) paragraph 9.4.19 needed to be amended to also specify when light units, where the designed main beam average intensity was above the value shown in Annex 14, Volume I, Appendix 2, were deemed unserviceable.

2.2.5.2 The meeting endorsed the above proposals for amendment to Annex 14, Volume I.

2.3 UPDATING OF THE *AERODROME DESIGN MANUAL*, PART 5

2.3.1 Current status of work

2.3.1.1 The rapporteur of the working group reviewed the progress of work on the updating of the *Aerodrome Design Manual*, Part 5 - *Electrical Systems* (Doc 9157). The working group had assigned the task of revising the manual to an *ad hoc* group. The *ad hoc* group was composed of panel members and advisers responsible for different sections of the manual. The rapporteur of the working group served as the rapporteur of the *ad hoc* group as well. At an early stage, the *ad hoc* group had concluded that the material in the existing manual was outdated and that an overall revision of the manual would be required.

2.3.1.2 The *ad hoc* group, which had commenced its work in early 1994, met fives times and the results of its work is compiled in Appendix B to the report of this agenda item. The proposed structure of the new manual, which had been endorsed by the working group at its seventh meeting in late 1995, was as follows:

Chapter 1	Introduction;
Chapter 2	Operational and dependability requirements;
Chapter 3	Electrical power supply;
Chapter 4	Electrical circuits for aerodrome lighting systems;
Chapter 5	Control and monitoring systems;
Chapter 6	Surface movement guidance and control systems;
Chapter 7	Lamps and luminaries;
Chapter 8	Electrical circuits for radio navigation aids;
Chapter 9	Installation design;
Chapter 10	Earthing and lightning protection of aerodrome electrical installations;
Chapter 11	Acceptance testing of aerodrome electrical installations; and
Chapter 12	Maintenance support.

2.3.1.3 The *ad hoc* group had concluded that it would not be possible to finalize the work on the updated manual in time for VAP/13. The members had been heavily engaged in other activities in the last year and little progress had been achieved during this period. Accordingly, the meeting was advised that the current draft of the revised manual was incomplete. Material for Chapters 6, 8, 9, 10, 11 and 12 was yet to be developed.

2.3.1.4 The *ad hoc* group had also recommended that the work of the International Electrotechnical Commission, Technical Committee 97 (IEC/TC97) should progress further before finalizing the work on the design manual. This was considered essential to avoid duplication of work and to facilitate cross-referencing as far as possible.

2.3.1.5 The Secretariat had suggested that the working group should be assisted by a consultant to finalize the task. However, the working group was of the opinion that the number of available consultants with sufficient expertise required to write a manual of this kind was very limited. Many of the known specialists, who were familiar with the development of SARPs in Annex 14, Volumes I and II as well as experienced in the design of electrical installations on aerodromes, were already engaged in the work of IEC/TC97.

2.3.2 **ICAO/IEC co-operation**

2.3.2.1 In this context, the rapporteur of the working group presented the following proposals for review by the meeting:

a) an ICAO/IEC Joint Study Group be set up to propose amendments to SARPs related to electrical systems in Annex 14, Volume I, Chapters 8 and 9;

b) the current *Aerodrome Design Manual*, Part 5 be withdrawn; and

c) the task of preparing the needed guidance on the design of aerodrome electrical systems conforming to SARPs in Annex 14, Volume I be carried out as a joint ICAO/IEC project.

2.3.2.2 The rapporteur further advised that a task including the development of a guide on compliance with the SARPs in Annex 14 related to electrical systems would be suitable for inclusion in the work programme of IEC/TC97. He believed that it would be feasible to complete such a guide for publication in early 2000. At that time, the first international standards developed by IEC/TC97 would be published.

2.3.3 **Development of SARPs related to design and monitoring of electrical systems**

2.3.3.1 The meeting saw no need for the establishment of a joint ICAO/IEC Joint Study Group as suggested by the rapporteur of the working group. The meeting considered that the development of SARPs related to design and monitoring of electrical systems in Annex 14, Volume I in the future should, as before, be accomplished with the assistance of the VAP or any other appropriate ICAO body of visual aids experts. The meeting also recommended that IEC should have one member in such a body of experts. In this context, it was pointed out that currently the Rapporteur as well as the Secretary of IEC/TC97 were also members of the ICAO Visual Aids Panel and that this should ensure co-ordination and liaison between the two organizations as required when developing SARPs related to design and monitoring of electrical systems.

2.3.4 **Need to withdraw the current *Aerodrome Design Manual*, Part 5**

2.3.4.1 The meeting recognized that the current *Aerodrome Design Manual*, Part 5 was outdated and in need of a complete revision. However, the meeting considered that, pending finalization of the revision of the manual, the current version should remain as a salable document. In this context, the meeting recommended that the manual be annotated to indicate that it was currently under revision. Accordingly, the meeting formulated Recommendation 2/3 to the report on this agenda item. One member did not agree that the manual should remain a salable document and thus did not support Recommendation 2/3.

2.3.5 **Finalizing the task of updating the *Aerodrome Design Manual*, Part 5**

2.3.5.1 The meeting could not review the current draft of the revised design manual. However, the meeting concluded that the task of updating the *Aerodrome Design Manual*, Part 5 could not be accomplished by the panel at this time. While the expertise was available within the present membership of the panel, the members did not have the resources to involve themselves to the extent necessary. In addition, the meeting agreed with the *ad hoc* group that, to avoid duplication of work efforts and to ensure the necessary co-ordination, the work of the IEC/TC97 would have to progress further prior to finalizing the manual. The meeting also saw the possibility of the design manual becoming redundant, once standards and guidance material in the areas of design and monitoring of related electrical systems for aeronautical ground lights had been further developed by IEC. As a result, the meeting considered that it would be premature at this time to take action to finalize the manual. Instead, the meeting agreed that the panel, in particular the members participating in the work of IEC/TC97, should assist the Secretariat in monitoring the work of the IEC/TC97 and recommend, at an appropriate time, whether a new manual would be needed. Accordingly, the meeting formulated Recommendation 2/4 to the report on this agenda item.

2.4 CONCLUSIONS

2.4.1 The meeting agreed that it had accomplished the assigned tasks under work programme Item 3 — Secondary power supply and design, except for the task of updating of the design manual.

2.4.2 In light of the foregoing, the meeting formulated the following recommendations:

RSPP **Recommendation 2/1 — Amendment to Annex 14, Volume I — Secondary power supply and design**

That Annex 14, Volume I be amended as indicated in Appendix A to the report on this agenda item.

Recommendation 2/2 — Protection date for aerodrome lighting systems

That a protection date for existing lighting systems not meeting the 1 second switch-over time requirement, no later than ten years from the date the proposed new definition of the term "switch-over time" becomes applicable, be introduced in Annex 14, Volume I, Chapter 8.

Recommendation 2/3 — The *Aerodrome Design Manual*, Part 5 — *Electrical Systems* (Doc 9157)

That the *Aerodrome Design Manual*, Part 5 be annotated to indicate that it is currently under revision.

Recommendation 2/4 — Updating of the *Aerodrome Design Manual*, Part 5 — *Electrical Systems* (Doc 9157)

That the current draft of the *Aerodrome Design Manual*, Part 5 included in Appendix B to the report on this agenda item be noted and that no further work be undertaken on the manual pending further development of IEC Standards and guidance material related to design and monitoring of electrical systems for aeronautical ground lights.

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APPENDIX A

PROPOSED AMENDMENT TO

INTERNATIONAL STANDARDS AND RECOMMENDED PRACTICES

AERODROMES

ANNEX 14 TO THE CONVENTION ON INTERNATIONAL CIVIL AVIATION

VOLUME I (AERODROME DESIGN AND OPERATIONS)

NOTES ON THE PRESENTATION OF THE PROPOSED AMENDMENT TO ANNEX 14, VOLUME I

The text of the amendment is arranged to show deleted text with a line through it and new text highlighted with grey shading, as shown below:

1.	~~Text to be deleted is shown with a line through it.~~	text to be deleted
2.	New text to be inserted is highlighted with grey shading.	new text to be inserted
3.	~~Text to be deleted is shown with a line through it~~ followed by the replacement text which is highlighted with grey shading.	new text to replace existing text

CHAPTER 1. GENERAL

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1.1 Definitions

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~~***Light failure.*** A light shall be considered to have failed when for any reason the average intensity determined using the specified angles of beam elevation, toe in and spread falls below 50 per cent of the specified average intensity of a new light.~~

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Switch-over time. The time required for the actual intensity of a light measured in a given direction to fall from 50 per cent and recover to 50 per cent during a power supply change-over, when the light is being operated at intensities of 25 per cent or above.

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CHAPTER 8. EQUIPMENT AND INSTALLATIONS

8.1 Secondary power supply

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Characteristics

8.1.2 **Recommendation.—** *Electric power supply connexions to those facilities for which secondary power is required should be so arranged that the facilities are automatically connected to the secondary power supply on failure of the normal source of power.*

8.1.3 **Recommendation.—** *The time interval between failure of the normal source of power and the complete restoration of the services required by 8.1.1 should be as short as practicable and should not exceed two minutes, except that for visual aids associated with non-precision, precision approach or take-off runways the requirements of Table 8-1 for maximum switch-over times should apply.*

Note 1.— In certain cases, less than thirty seconds has been found to be attainable.

Note 2.— A definition of switch-over time is given in Chapter 1.

8.1.4 **Recommendation.—** *Requirements for a secondary power supply should be met by either of the following:*

— *independent public power, which is a source of power supplying the aerodrome service from a substation other than the normal substation through a transmission line following a route different from the normal power supply route and such that the possibility of a simultaneous failure of the normal and independent public power supplies is extremely remote; or*

— *standby power unit(s), which are engine generators, batteries, etc., from which electric power can be obtained.*

Note.— Guidance on secondary power supply is given in the Aerodrome Design Manual, *Part 5.*

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Table 8-1. Secondary power supply requirements
(see 8.1.3)

Runway	Lighting aids requiring power	Maximum switch-over time
Non-instrument	Visual approach slope indicators[a]	See 8.1.3 and 8.1.5
	Runway edge[b]	
	Runway threshold[b]	
	Runway end[b]	
	Obstacle[a]	
Non-precision approach	Approach lighting system	15 seconds
	Visual approach slope indicators[a,d]	15 seconds
	Runway edge[d]	15 seconds
	Runway threshold[d]	15 seconds
	Runway end	15 seconds
	Obstacle[a]	15 seconds
Precision approach category I	Approach lighting system	15 seconds
	Runway edge[d]	15 seconds
	Visual approach slope indicators[a,d]	15 seconds
	Runway threshold[d]	15 seconds
	Runway end	15 seconds
	Essential taxiway[a]	15 seconds
	Obstacle[a]	15 seconds
Precision approach category II/III	Approach lighting system	15 seconds
	Supplementary approach lighting barrettes	1 second
	Obstacle[a]	15 seconds
	Runway edge	15 seconds
	Runway threshold	1 second
	Runway end	1 second
	Runway centre line	1 second
	Runway touchdown zone	1 second
	All stop bars	1 second
	Essential taxiway	15 seconds
Runway meant for take-off in runway visual range conditions less than a value of ~~550~~ 800 m.	Runway edge	15 seconds[c]
	Runway end	1 second
	Runway centre line	1 second
	All stop bars	1 second
	Essential taxiway[a]	15 seconds
	Obstacle[a]	15 seconds

a. Supplied with secondary power when their operation is essential to the safety of flight operation.
b. See Chapter 5, 5.3.2 regarding the use of emergency lighting.
c. One second where no runway centre line lights are provided.
d. One second where approaches are over hazardous or precipitous terrain.

8.1.8 For a runway meant for take-off in runway visual range conditions less than a value of ~~550 m~~ 800 m, a secondary power supply capable of meeting the relevant requirements of Table 8-1 shall be provided.

Note.— Guidance on electrical systems is included in the Aerodrome Design Manual, *Part 5 —* Electrical Systems *(Doc 9157).*

CHAPTER 9. EMERGENCY AND OTHER SERVICES

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9.4 Maintenance

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Visual aids

Note.— ~~These specifications are not intended to define the operational failure of a lighting system.~~ These specifications are intended to define the maintenance performance level objectives. They are not intended to define whether the lighting system is operationally out of service.

9.4.19 A light shall be deemed to be unserviceable when the main beam ~~is out of its alignment or when its~~ average intensity is less than 50 per cent of the ~~specified value~~ value specified in the appropriate figure in Appendix 2. For light units where the designed main beam average intensity is above the value shown in Appendix 2, the 50 per cent value shall be related to that design value.

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APPENDIX B

(In English only)

AERODROME DESIGN MANUAL

(17/4/97)

DRAFT

Part 5

ELECTRICAL SYSTEMS

SECOND EDITION — 1998

INTERNATIONAL CIVIL AVIATION ORGANIZATION

FOREWORD

Proper design, installation and maintenance of electrical systems for navigation aids, both visual and non-visual, are prerequisites for the safety, regularity and efficiency of civil aviation. To this end, this manual provides guidance on the design, installation and maintenance of electrical systems for aerodrome lighting and radio navigation aids.

The electrical systems installations for aerodrome lighting and radio navigation aids include features which are not usually involved in other electrical installations. This manual, therefore, discusses not only the general features of electrical practices and installations, but also is focusing on those features which are of special significance for the operational requirements of aerodrome installations. It is assumed that readers of the manual will be familiar with electrical circuits and general design concepts, but may not be knowledgeable of certain features of aerodrome installations which are less frequently normally not encountered in other installations. It is important to note that the material presented in this manual is intended to compliment national safety codes related to electrical installations. All installations should, where possible, comply with national safety regulations. However, many countries find difficulties in applying the national safety regulations to aerodrome installations, since safety regulations, in general, are intended to cover electrical installations of buildings. In some countries the regulatory authorities will accept compliance with a recognised standard in lieu of the national safety regulations. In this manual reference is made to standards issued by International Electrotechnical Commission (IEC), Technical Committee No. 97. The IEC Standards are intended to cover all safety aspects in relation to series circuits on aerodromes and compliance with the IEC Standards should provide a means of resolving conflicts with national regulations written for parallel circuits normally associated with installations of buildings.

It is of paramount importance that personnel involved in the design, installation and maintenance of visual and radio navigational aids have received formal training in the basic airport operational and technical disciplines.

The manual does not discuss electrical systems for buildings located on an airport other than the effect of such buildings on total power requirements for primary and secondary power supplies. Similarly, the manual does not deal with the maintenance of electrical systems. Maintainability performance and maintenance support performance requirements are addressed in the manual. Guidance on establishing maintenance programmes for airport electrical systems is given in the *Airport Services Manual*, Part 9 — *Airport Maintenance Practices* (Doc 9137).

Future editions of this manual will be improved on the basis of experience gained and of comments and suggestions received from users of this manual. Readers of this manual are invited to give their views, comments and suggestions to the Secretary General of ICAO.

Table of contents

CHAPTER 1. INTRODUCTION

1.1 SCOPE

Operational requirements on the electrical installations for navigational aids on an aerodrome are included in the **Standards and Recommended Practices** (SARPs) published in Chapters 8 and 9 in Volume I of Annex 14 to the Convention on International Civil Aviation, Volume I, Aerodrome Design and Operations. The majority of the electrical installations on an aerodrome which supply power to operational systems are associated with the visual aids for which SARPs are detailed in Chapters 5, 6 and 7 in Volume I of Annex 14 to the Convention on International Civil Aviation. Specifications for secondary power supply for radio navigational aids and ground elements of communications systems are given in Chapter 2 in Volume I, Part 1 of Annex 10 to the Convention on International Civil Aviation.

This manual provides guidance on electrical engineering practices for the design, installation and maintenance of new or modifications to existing electrical systems on an aerodrome. The manual may also, to a certain extent, be used as a guide to the recommended electrical engineering practices for design and installation of visual aids for heliports (as defined in Volume II of Annex 14 to the Convention on International Civil Aviation).

International standards for electrical installations for lighting and beaconing of aerodromes are being developed by IEC Technical Committee No. 97. Standards covering the fundamental principles for the constant current series circuit and electrical and mechanical interfaces between components in the lighting systems are being prepared by IEC/TC97. Where appropriate this manual refers to those standards.

1.2 PURPOSE

SARPs adopted by the Council of ICAO are defined as any specification for physical characteristics, configuration, equipment, performance, personnel or procedure, the uniform application of which is recognised as necessary or desirable for the **safety, regularity or efficiency** of international air navigation. Safety, regularity and efficiency are qualitative terms used in specification of operational requirements. The purpose of this manual is to provide guidance on acceptable means of complying with the SARPs expressed in terms normally used in the design and engineering process.

This manual is primarily intended for following categories:

- consultants engaged in the design and engineering of electrical systems of aerodromes;
- aerodrome engineers;
- trainees; and
- authorities regulating electrical installations of aerodromes

The manual contains information on the following subjects:

- guidance on the interpretation of SARPs in Annex 14;
- information on typical applications;
- guidance on performance requirements;
- guidance on maintenance requirements; and
- tender evaluation.

It is assumed that those using this manual will be familiar with electrical circuits for normal power distribution systems. However, they may not have knowledge of certain features of aerodrome installations.

Except for smaller aerodromes with very limited lighting facilities, contemporary lighting installations use constant current series circuits for the distribution of power to the various lighting systems. Therefore, as concerns airfield ground lighting applications, this manual only describes the constant current series circuits.

The recommendation of particular engineering practices for electrical design and installation in this manual does not imply that existing installations using other practices should be changed immediately to comply with the guidance in this manual. It may, however, mean that some of the earlier designs are not recommended for repetition since they have been superseded by later developments.

1.3 TECHNICAL DOCUMENTATION

The electrical systems are becoming increasingly complex and require a comprehensive documentation, which shall accompany the system throughout its existence. The technical documentation is the medium through which the electrical installations will be operated and maintained. It is important that this can be done in a safe and economical way.

The installations and systems shall be considered as a whole and the respective elements as integral parts of the complete installation. This view is of primary importance for the engineering process and the way it is documented. The documentation is essential for the managing, commissioning, operation and maintenance of an installation or a system and the documentation should be presented in accordance with a standard structure.

It is recognised that the information on the electrical systems can be organised with tree-like structures. The structure represents the way the process or system is subdivided into smaller sub-processes or subsystems. Structuring principles and a reference designation system in accordance with IEC/ISO standards should be applied to the documentation of aerodrome electrical systems.

Attachment A to this manual shows examples of functionally oriented documentation structure and overview diagrams.

1.4 DEFINITIONS

Terms used in the manual which are not self-explanatory and do not have accepted dictionary meanings are listed herein. The definitions are divided in two groups. The first group comprises established ICAO terms which are used in specifications of aeronautical ground lighting systems. The second group comprises terms defined by the International Electrotechnical Commission (IEC).

1.4.1 ICAO terms

SARPs — Standards and Recommended Practices adopted by the Council of ICAO and published in an Annex to the Convention on Civil Aviation.

Aerodrome beacon — Aeronautical beacon used to indicate the location of an aerodrome from the air.

Aeronautical beacon — An aeronautical ground light visible at all azimuths, either continuously or intermittently, to designate a particular point on the earth.

Aeronautical ground light — Any light specially provided as an aid to air navigation, other than light displayed on an aircraft.

Capacitor discharge light — A lamp in which high-intensity flashes of extremely short duration are produced by a discharge of electricity at high voltage through a gas enclosed in a tube.

Fixed light — A light having constant luminous intensity observed from a fixed point.

1.4.2 IEC terms

Luminaire — An apparatus which distributes, filters or transforms the light transmitted from one or more lamps and which includes, except the lamps themselves, all the parts necessary for fixing and protecting the lamps and, where necessary, circuit auxiliaries together with the means for connecting them to the electric supply.

Note.— The terms "lighting fitting" or "lighting fixture" are deprecated.

Luminous efficacy (of a light source) — The quotient of the luminous flux emitted by the power consumed by the source. Unit: $lm * W^{-1}$.

Lamp life — The total time for which a lamp has been operated before it becomes useless, or is considered to be in accordance to specified criteria. Lamp life is usually expressed in hours (h).

Useful life (of an item)	Under given conditions, the time interval beginning at a given instant of time, and ending when the failure intensity becomes unacceptable or when the item is considered unrepairable as a result of a fault.
Average (lamp) life	The average of the individual lives of the lamps subjected to a life test, the lamps being operated under specific conditions and at the end of life judges according to specific criteria.

1.5 REFERENCES

CHAPTER 2. OPERATIONAL AND DEPENDABILITY REQUIREMENTS

2.1 GENERAL

SARPs in Annex 14 are specifications of system characteristics in terms generally regarded as operational requirements. The SARPs are focusing on safety, regularity and efficiency.

The safety requirements apply to the process of risk management and incorporates many different elements from the initial identification and analysis of risk, to the evaluation of its tolerability and identification of potential risk reduction options. The regularity requirements address the availability performance of the system. Dependability is the collective term used to describe the availability performance and its influencing factors, i.e. reliability performance, maintainability performance and maintenance support performance. The efficiency of the system is evaluated by life cycle cost analysis.

In the design and engineering process the system characteristics need to be specified in terms defining the capability and dependability performance of the system.

Dependability requirements are often complex and in order to achieve them it is necessary to allocate appropriate resources, carefully planned and co-ordinated, into a dependability programme. Although the terms availability and safety are not synonymous by definition a risk management process is considered an essential element in the over-all dependability programme. Both availability performance requirements and safety requirements address reliability performance, maintainability performance and maintenance support performance but different aspects are applied. A risk analysis comprises the following elements:

- hazard identification;
- analysis of the frequency of occurrence of critical faults; and
- consequence analysis.

Guidance on dependability programme management, its elements and tasks, and methodology can be found in IEC 300[1].

In electrical installations of aerodromes reliability, availability and maintainability are essential performance characteristics. The levels of reliability, maintainability, availability and maintenance support performance of a system depends on the environment in which the system will be installed and operate. When the dependability requirements are specified it is necessary to specify the conditions

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[1] IEC 300 consists of the following parts, under the general title *Dependability management*:
Part 1: Dependability programme management
Part 2: Dependability programme elements and tasks
Part 3: A series of application guides

under which the system will operate. In addition, the maintenance policy and organisation for the maintenance support should be taken into account.

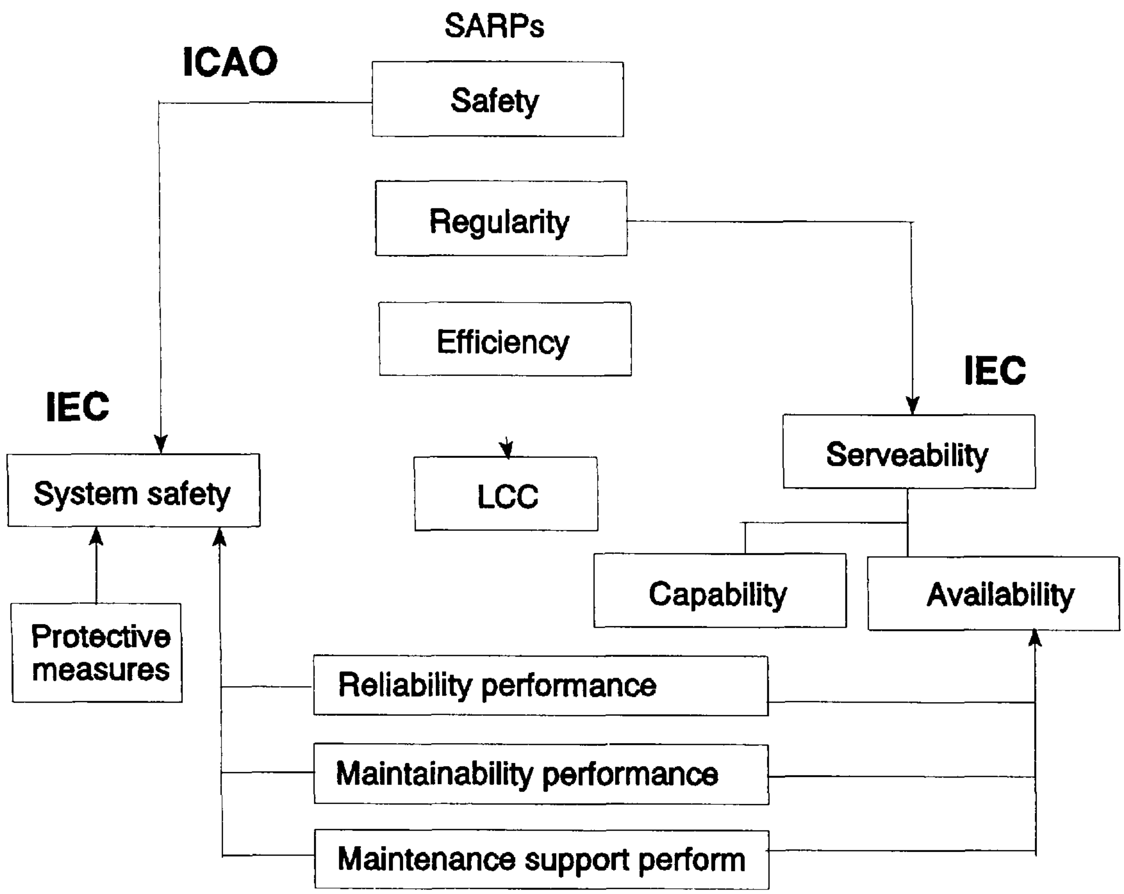

Fig. x. Relation between the ICAO safety, regularity and efficiency requirements and system safety, dependability and life cycle cost requirements

This manual provides guidance on the design and installation of electrical systems with the objective of achieving systems which meet the safety requirements specified in Annex 14. However, each aerodrome is unique and the regularity demands may differ between the aerodromes. Since there can be considerable differences between the costs of different designs of the electrical systems a dependability analysis should always be included in the design and engineering process. All reliability, maintainability and availability requirements should be expressed quantitatively wherever possible but it may also be appropriate to include qualitative requirements in the specifications. It may not always be possible to specify the safety requirements in quantitative terms.

The specifications should also define procedures to be used to give assurance that the specified reliability, maintainability and availability performance requirements are met. It is essential that requirements are verifiable and that methods of verification conforming to IEC Standards are used. To assess the values of the dependability characteristics it is necessary to use statistical methods. It is essential that the specified requirements are realistic and compatible with the technological state of the art.

2.2 POWER SUPPLY

SARPs covering the secondary power supply requirements are specified in Annex 14, Volume I, Section 8.1. A high availability of the power supply to the lighting facilities is required both for safety and regularity reasons. Values of the availability of both the primary and secondary power supply should be obtained so that the total availability of the power supply can be determined. A very low availability of the primary power supply may be unacceptable even though the basic requirements are met by the provision of a secondary power supply in the form of a stand-by unit.

The availability of stand-by units is much dependent on the maintenance support performance. The units require frequent testing and should be closely supervised. They are high cost items, particularly when the life cycle costs are considered, and a dependability analysis of the secondary power supply system should include alternative solutions.

Guidance on the design of the power supply systems is given in Chapter 3 of this manual.

2.3 DESIGN FOR SAFETY

"Fail safe" is defined as a property of an item which prevents its failures from resulting in critical faults. A critical fault is a fault which is assessed as likely to result in injury to persons, significant material damage, or other unacceptable consequences.

The requirement of fail safe design is specifically addressed in Annex 14, Volume I, paragraph 8.2.1, which reads:

> *"For a runway meant for use in a runway visual range conditions less than a value of 550 m, the electrical systems for power supply, lighting and control of the lighting systems included in Table 8-1 shall be so designed that an equipment failure will not leave the pilot without visual guidance or misleading information."*

Note.— This requirement applies as a Standard to "runways meant for use in runway visual range conditions less than a value of 550 m" only. It is, however, prudent to consider the requirement in all safety management programmes related to aeronautical ground lighting systems.

A means of complying with this requirement is to use duplicate interleaved series circuits for all lighting circuits requiring a maximum switch-over time of one second as specified in Table 8-2 of Annex 14, Volume I. It should, however, be observed that interleaving primarily is a risk reduction measure. A regulator fault in a subsystem supplied by two interleaved circuits may result in the subsystem being unserviceable based on the serviceability criteria established by the appropriate authority in a certification programme.

The term "serviceability" is used but not defined in Annex 14. The following definition[2] is given in IEC 50(191):

> *"Serviceability performance is the ability of a service to be obtained within specified tolerances and other given conditions when requested by the user and continue to be provided for a requested duration"*

Thus, in this definition the term serviceability performance includes both the capability and the availability performance.

Note.— It should be observed that the minimum "serviceability level" specified by the appropriate authority, below which operations should not continue, is not necessarily the same as the operational state which is the result of a critical fault. The number of faulty lights in a lighting element which may be accepted before the lighting element is determined to be unsuitable for normal operation may be lower than the number of faulty lights in the lighting element, which constitutes a critical system fault.

2.4 SPECIFICATION OF AVAILABILITY PERFORMANCE REQUIREMENTS

Availability performance requirements should be specified for systems where down time could cause considerable economic loss or personnel injury, which is often the case for electrical installations of aerodromes. Availability performance can be calculated from the system configuration, its subsystems and their reliability performance and maintainability performance requirements, if stated, and by taking into account the maintenance support conditions.

Maintainability performance requirements should be specified for equipment when the maintenance costs contribute significantly to the life cycle cost or if minimum repair time is essential for the user. A preventive maintenance programme should be specified for all equipment included in an aerodrome lighting system.

For aerodrome lighting systems redundancy and maintenance should be considered together. It is therefore appropriate at system level to specify availability requirements rather than separate reliability and maintainability requirements. It is neither necessary nor desirable to specify all three dependability characteristics. Two of the three are sufficient. However, in most cases it is insufficient to specify only the availability performance. A reliability performance measure such as mean failure intensity may also be specified.

2.5 REDUNDANCY

Redundancy has the meaning that, in a system, there exist more than one means for performing a required function.

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[2] This definition is commonly used in specifications of telecommunication systems.

An active redundancy is that redundancy wherein all means for performing the required function are intended to operate simultaneously. Active redundancy is often provided for communication links to improve the availability of the remote control systems for lighting circuits.

Passive (or stand-by) redundancy is that redundancy wherein a part of the means for performing the required function is intended to operate, while the remaining part(s) of the means are inoperative until needed. An example of passive redundancy is the stand-by power unit normally provided for lighting circuits for precision approach runways as secondary power supply.

Redundancies are not always effective and may have undesirable side-effects. The desired effect of the redundancy will be achieved only if faults are detected and corrected. This means that all redundant parts need to be monitored.

Redundancy will make the system more complex, not only because of the duplication of components or equipment but also due to needed additional testing and switching devices. Increased complexity will result in higher costs and sometimes lower availability. The increased complexity will make maintenance more complicated and will increase the risk for unanticipated faults for which no prevented measures have been taken.

Redundancies should therefore be used with some restraint and the decision to use redundancies should be based on careful studies based on dependability analyses. An alternative approach may be found in the design of monitoring systems or the engineering of maintenance support systems.

2.6 MAINTENANCE SUPPORT PERFORMANCE

2.6.1 General

Maintenance support is the ability to provide resources required to maintain the system. Maintenance support is required during the operation and maintenance phase of the life cycle, but may also be required during the installation phase. Maintenance support engineering includes specification of procedures, tools, test equipment, documentation and training programme for the maintenance personnel.

Maintenance support engineering should be based on a **maintenance policy**. The maintenance policy is a description of the interrelationship between the maintenance echelons, the indenture levels and the levels of maintenance to be applied for the maintenance of the systems.

Guidance on maintenance support engineering is given in Chapter 12 of this manual.

2.6.2 Reliability centred maintenance (RCM)

Traditional maintenance has been oriented towards repair work (corrective maintenance). The designers have not had sufficient knowledge of maintenance work to do good job on the maintainability of the equipment. No systematic collection of operational experience has been made. However, the development towards remotely monitored systems and computer aided design and engineering has led to new techniques which will make it possible to integrate the design, engineering and operation phases. RCM is intended to cover the entire life cycle of the system.

RCM is a method for establishing a scheduled preventive maintenance programme which will efficiently and effectively allow the achievement of the required safety and availability levels.

RCM starts with definition of the structure of the system and essential performance requirements. Data on faults and maintenance action are registered during the operation phase of the life cycle. The data are analysed using statistical methods. Technical analyses are performed to determine the causes of failures and faults and to propose modifications of the design or the operating criteria of the system.

RCM includes identification of those items in the system which have significant influences on the safety and dependability of the system and have high maintenance costs. These items are called functionally significant Items.

In addition, data on environmental and other conditions of use needed for technical and statistical analyses, should be collected.

In order to be timely and effectively performed, the RCM activities may require dedicated management resources. A large aerodrome may, for example, establish a fault review board.

Guidance on RCM can be found in IEC 300-3-11[3].

2.7 ELECTROMAGNETIC COMPATIBILITY (EMC)

Electrical installations of aerodromes must not cause radiated or conducted electromagnetic interference to other systems such as information technology equipment (ITE), or radio navigational aids that may be located on or near the aerodrome, or that may use the same power supply. All equipment included in the electrical systems shall have immunity to electromagnetic phenomena such electromagnetic fields from radio transmitters, transients on power lines, electrostatic discharges etc.

The term "electromagnetic compatibility (EMC)", is defined as the ability of an equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment. For specification of EMC requirements reference is made to appropriate IEC Standards.

[3] The document is in preparation and is expected to be published 1998-99.

CHAPTER 3. ELECTRICAL POWER SUPPLY

3.1 GENERAL

The primary sources of power for aerodromes should be determined before the designs of the aerodrome lighting installations and the radio navigation aids are initiated. The electrical power for these installations is usually only a small part of the electrical power used by the aerodrome. Whether the visual and radio navigation aids being installed are for a new aerodrome or for modernisation and expansion of an existing aerodrome, the sources of power should be analysed for availability, capacity, reliability, practicality for the proposed installation and for future expansion. This analysis should include both the primary power source and the secondary power source required by Annex 10, Volume I, Part I, 2.9 and Annex 14, Volume I, 8.1 for use in cases of failure or malfunction of the primary power source. The provision or requirement of a standby power source should also be considered.

Good, efficient maintenance is essential in supporting a reliable power supply. However, it is essential to consider methods or providing adequate cost effective redundancy in the system design.

Redundancy is where failed items become superfluous to continued operation. Contingency is where alternatives are available in case of failures.

An electrical system is described as having zero contingency and no redundancy, when the failure of any element in the system will result in a loss of service and no alternative.

In a primary contingency system, the loss of a single item such as a transformer or feeder will not result in a loss of service.

In a secondary contingency system, the loss of up to two items can be tolerated without affecting the operation of the system.

3.2 POWER SUPPLY

It is desirable to improve the availability of the primary power system by having two incoming feeders, each originating from externally separate substations which are fed from different parts of a grid system or from different generators.

This power is often supplied at a nominal voltage of 11 kV to the aerodrome main power substation or substations.

With the aim of maintaining a power supply to an aerodrome at all times, a secondary supply should be available in reserve. To this end, automatic transfer of the load from the primary to a secondary supply or standby plant should take place on loss of primary power. The intervention of hardware or software is unacceptable, if it relies on the power to be present to process the information. Manual or automatic load return to the primary power source should only be undertaken after the primary source has been proved to be stable and available again for at least 15 minutes. Another loss of primary power within 15 minutes should require a manual return of load only.

3.3 SECONDARY POWER SUPPLY

Most aerodromes equipped with aerodrome ground lighting and radio navigational aids are provided with secondary electrical power as required by Annex 14, Volume I, Chapter 8 for visual aids and Annex 10, Volume I, Part I, Chapter 2 for radio navigational aids. The circuits and facilities to be provided with secondary power vary according to the type of operations conducted at the aerodrome. Sources of secondary power may be independent public power supply or standby power units.

Secondary electrical power should be of such quality that it will provide the reliability, availability and voltages and frequencies needed by the facility. The major equipment used to generate secondary standby power for aerodrome lighting and radio navigation aids are engine-generator sets, power-transfer switching devices, batteries and invertors. Vaults or shelters are commonly used to house the equipment. Less often used are uninterruptible power (UPS) systems, standby battery-power systems, solar or wind generators, independent generating devices such as thermoelectric, nuclear, or fuel cells. Standby power equipment should be located as close as is practical to the facilities served.

Another arrangement that meets the requirement for continuity of service is to supply the power for the aerodrome lighting and radio navigational aids from generator sets which may also be supplying power to other facilities. If this source of power fails, the critical lighting and radio aids load may be transferred automatically to the primary power source for the aerodrome.

3.3.1 Commercial or public mains power supply

For aerodromes being fed with external primary and secondary supplies of electricity, separate independent electrical transmission power lines with a minimum separation of 30 m for overhead lines and 6 m for underground cables should be used to provide the primary and secondary power. The secondary power supply is not normally supplying the aerodrome ground lighting and radio navigation aids loads but should be automatically switched to these loads in case of failure of primary power supply. A secondary supply normally providing power for other facilities should have adequate capacity to provide the power for the more critical aerodrome lighting and radio navigation aids in addition to the usual load, or switching arrangements should be provided to disconnect, as appropriate, its usual load as it is connected to the critical lighting and radio aids. The required availability provided by the secondary power source depends on the separation and independence of this source from the primary source. If the two sources come from interconnected distribution networks, a failure in the network may cause both sources to fail. A totally independent power source may also be used as a secondary power source if it has the capacity to supply its own load plus the aerodrome lighting and radio aids load and is so separated that any single cause of power failure of the primary source will not interfere with power from the independent source.

3.3.2 Local power source

If an aerodrome has a generator which is used to supply electrical power to non-critical facilities, it may be considered as an independent local power source. Such local power sources may be used as the secondary source of power for critical aerodrome lighting and radio navigational aids. If the primary power fails, the critical lighting and radio aids are transferred automatically to the local power source. If the local power source has adequate capacity, the lighting and radio aids load may be in addition to the usual load. If the capacity of the local power source is limited, the local power source may need to disconnect some of the non-critical load before connecting to the critical lighting and radio aids load.

3.3.3 Standby generating equipment

The maximum load to be connected should be within the capacity of the standby units. Capacities ranging from 50 to more than 1,000 kilovolt-amperes are typically used as power sources for airports. The standby power source should be capable of supplying power for a time period of not less than 6 hours and should also provide power for a period that exceeds the maximum time expected to restore power from the primary source. Engine-generator sets are often expected to operate for 24 to 72 hours without refuelling. Standby or secondary power sources, usually for small loads, may be battery units, fuel cells, etc.

3.3.4 Engine generator sets

Engine-generator sets normally consist of a prime mover, generator, starting device, automatic controls and a fuel tank or supply. When used for secondary or standby power supplies, they are preferred dedicated to aerodrome traffic visual and radio aids and co-located with the associated substation.

Prime movers

The prime movers for most power units are gasoline, diesel, or gas engines or turbines, the choice being based on cost and availability of fuels. These prime movers are usually available in standardised sizes with adequate power to handle the kilovolt-ampere rating of the generator. The prime movers for most major aerodromes are rapid-start types which can start automatically, stabilise the speed and be connected to the load within 10 seconds.

Generators

The generator, usually an alternator, is mechanically coupled to the prime mover and provides electrical power at the frequency, voltage and power rating of the unit. They should have high efficiency in converting mechanical energy to electrical energy and able to handle the harmonic content likely to be encountered with aerodrome lighting installations. For three phase alternators, the output voltage control should be capable of accepting any expected out of balance loads liable to be in use.

Starting devices

Most engine-generator sets use battery packs to store energy for starting. Because of the infrequent use, short operating periods, high starting current demands and cost, lead-acid type batteries are normally used for starting these units. The battery pack (often a set of batteries connected in series and/or parallel) must be capable of providing the voltage and current needed to start the engine within the required time limits and under the most severe environmental conditions in which the power unit is expected to operate. A battery charger with over-current and over-charge control is permanently connected to the electrical power to maintain the stored energy in the batteries. The battery pack should be well ventilated to prevent accumulation of hydrogen gas and should be protected from arcs, sparks, or flames which could cause an explosion of any accumulated gas.

Nickel-cadmium batteries may be used where special circumstances warrant their high initial cost. Other means of starting such as flywheels, pneumatic pressure vessels etc., are used but not preferred because of poor reliability and high cost.

Starting controls

An engine-generator set starting sequence is usually initiated by a signal from the power transfer switching device sensing a primary power failure. Manual or remote controls are sometimes used for facilities with low critical requirements. The starting sequence may also be initiated if the engine generator set is operationally required to become the primary source of electrical power. Once started, speed and power are expected to be automatically regulated by the engine controls and the electrical load automatically connected by the transfer switch, no manual attention should be required. Transfer of electrical power back to the primary source and engine stopping should be manual by local or remote control, with a minimum running time of 15 minutes after either the primary power source has become available again or the starting sequence has been initiated. A local emergency stopping facility must be provided.

Fuel supply

Liquid fuel for standby or secondary power units is usually stored in tanks near the engine-generator location. The capacity of the fuel tanks should be adequate for the maximum operating time expected of the engine-generator. Some authorities require a minimum of 72 hours supply. Others design for a lesser time period, but the time period should be at least twice the maximum duration expected of conditions that could require the use of secondary or standby power and never less than 6 hours. Fuel tanks and connections should meet all safety requirements and should provide convenient access for refuelling. These tanks should also provide arrangements for testing for contamination of the fuel, especially the accumulation of water in the tank.

3.3.5 Uninterruptible power supply (UPS) systems

An uninterruptible on-line electric power supply is necessary for electronic or other equipment that performs a critical function and requires continuous, disturbance-free electric power to operate properly.

3.3.6 UPS equipment

The uninterruptible on-line power supply (UPS) system consists of one or more UPS modules, an energy-storage device and accessories as required to provide a reliable and high quality power supply. The UPS system isolates the load from the primary and secondary sources and in the event of a power interruption provides continuous regulated power to the critical load for a specified period. (See Figure 3.4.)

UPS module

A UPS module is the static power conversion portion of the UPS system and consists of a rectifier, inverter and associated controls along with synchronising, protective and auxiliary devices. UPS modules may be designed to operate either individually or in parallel.

Redundancy

A non-redundant UPS system is suitable for most applications. However, if the expense is justified, a redundant UPS configuration may be used to protect against module failure or frequent primary power failures.

UPS battery

The battery should be a heavy-duty type having an ampere-hour rating sufficient to supply direct current to the inverter as required by the UPS system installation instructions.

3.4 SWITCH OVER FROM PRIMARY TO SECONDARY POWER

3.4.1 Definition of the term "1 second switch-over time"

Depending on the transfer time required, the secondary power source must be instantly available or the generator set started having speed and voltage stabilised before the load is transferred.

The transfer, or switch-over times permitted depend on the most critical classification of the aerodrome's operation. Annex 14, Volume I, Chapter 8 and Annex 10, Volume I, Part I, Attachment C list the maximum permissible transfer times for the components of aerodrome lighting systems and radio aids associated with non-instrument, non-precision and precision approach runway categories I, II, III and take-off runways intended for use in runway visual range conditions less than a value of the order of 550 m (see Table 3.5.1).

When the primary power supply to the visual and radio navigation aids fails, the load must be transferred to the secondary power source. Once the primary power supply is restored, the time of switch-back should be an operational decision.

3.4.2 Methods of obtaining the required switch-over time

The following methods are suggested as possible ways to restore the power supply within the specified maximum switch-over times. It is advantageous to group loads with similar limiting switch-over times so that they may be controlled collectively at the transformer supply or at the feeder distribution connections.

15 seconds switch-over time

Where a 15-second maximum switch-over time is required, standby diesel and gasoline engine-generator sets with rapid-start capability and fast-acting automatic switching or an independent power source with automatic transfer switching can be used. To minimise standby supply surges on taking load, initial transfer may take place when at least 80 per cent of the nominal voltage has been achieved.

10 seconds switch-over time

Where a 10 second switch-over time is required for ILS equipment, secondary power units, such as petrol driven sets with suitable starting and switch-over capability can be used but location of UPS at the ILS site is now common practise.

1 second switch-over time

Where a one second switch-over time is required, one of the following methods can be used:

a) two independent power supplies;
b) one standby generator;
c) kinetic energy store; or
d) battery backup for CRCs

The choice of method is determined by cost implications and environmental impact.

3.4.3 **Uninterruptible power supplies**

There are normally two basic types of uninterruptible power supplies, ones includes a brief power interruption during its switching operation and the other is truly uninterruptible.

Some communication and visual aids are capable of accommodating brief power interruptions, but computers, some types of lamps etc. require a truly stable and uninterruptible power supply.

Where a truly uninterruptible power supply (UPS) is required, battery driven or Kinetic energy maintained equipment may be used. To meet operational needs, if the batteries are used they must be capable of sustaining the "on-line" power supply for a critical time period. The critical time period will be determined by considering the flight safety issues associated with completing any landing or take-off operation and the time associated with introducing a permanent secondary power supply.

UPS systems may also be built into equipment, such as constant current regulators, thereby eliminating the need for providing large scale power transfer devices.

3.5 DISTRIBUTION OF POWER

The voltage from the primary power source or sources in the case of duplicate feeders, is usually reduced in voltage at an aerodrome substation for distribution within the aerodrome. Distribution within the aerodrome may be at 11 kV or 400/230 V, depending on the size and layout of the aerodrome. The power is usually distributed by a "parallel" system to the various substations within an aerodrome and where necessary, for further step-down of voltage to match the input voltage of equipment.

Two independent incoming electrical supplies taken from widely separated sections of the electricity network beyond the aerodrome are recommended. Alternative routes and duplicate feeders for power may be necessary not only during possible fault conditions, but also for periods of routine maintenance and installation extensions. It is important to ensure alternative power routes are adequately spaced not only to avoid a single incident cutting off both supplies, but also to enable work to be carried out on one supply with the other still in service.

Within the aerodrome, reliability in the supply of power to the individual substations can be improved by using a closed ring high voltage input circuit with balanced voltage protection on the distribution cables or by using a double loop system from independent primary sources operating as open rings feeding two transformers at each station. This latter system is illustrated in Figure 3.3. If a centralised monitoring system of the loop switches at each station and of fault currents likely to occur in each section is used, practically complete elimination of total power failures to the substations can be achieved. Simpler arrangements providing lesser reliability may be appropriate, typical being unit protection.

Example of an intermediate voltage distribution network using unit protection

Fig. xx

Under normal conditions all circuit breakers are closed, except for the one providing the secondary supply.

Having duplicate feeders, supply A or B may be selected as the "main" with the other acting as "standby". The 1 second power transfer facility is provided by an automatic no-voltage changeover arrangement between supplies A and B.

Should a cable fault occur, then the circuit breakers feeding the section will automatically trip and localise the failure with least operational inconvenience and no interruption of power to the airfield substations.

Alternative contribution from Sweden (different approach; incomplete)

CHAPTER 3. ELECTRICAL POWER SUPPLY

3.2 GENERAL

The normal source of power for the aerodrome should be determined before the designs of aerodrome lighting installations and the radio navigation aids are initiated. The electrical power for these installations is usually only a small part of the total electrical power used by the aerodrome. Whether the visual and radio navigational aids being installed are for a new aerodrome or for modernisation of an existing aerodrome the sources of power should be analysed for availability, capacity, and practicality for the proposed installation and for future expansion. This analysis should include both the normal power source and the secondary power source required by Annex 10, Volume I, Part I, Section 2.9 and Annex 14, Volume I, Section 8.1, for use in cases of failure of the normal power source.

The analysis may show that is desirable to improve the availability of the normal power supply. This can be achieved by providing duplicate incoming feeders, each originating from externally separate substations which are fed from different parts of a grid system or from different generators.

3.2 SECONDARY POWER SUPPLY

Sources of secondary power may be independent public power supply or stand-by power units.

If an independent public power source is chosen, the transmission from the independent public power source shall follow a different route than the route for transmission line from the normal power source. The independent public power source shall be selected so that the probability of a simultaneous failure of this power source and the normal power source is extremely remote (Annex 14, Volume I, paragraph 8.1.4). A separate transmission line to a truly independent public power source is usually difficult to accomplish within reasonable cost limits and this solution is therefore seldom used.

Stand-by power equipment should be located as close to the facilities served as is practical. In the case more than one substation is used for distribution of power to the visual and radio navigational aids stand-by power units may have to be installed in each substation. If a centralised stand-by power system is selected a separate high voltage distribution to the substations will be required and the switch-over from normal power supply to the secondary power supply should take place in the respective substation.

The secondary power supply shall have the serviceability required by the served facilities. This implies that the secondary power supply needs to be monitored and subject to a preventive maintenance programme.

3.2.1 **Stand-by generating equipment**

Engine driven generator sets

International standards for reciprocating internal combustion (RIC) engine driven generator sets are published in ISO 8528. Performance class G3 or better should be specified when the RIC engine driven generator set is used as secondary power supply for visual and radio navigation aids on aerodromes. Supplementary specifications may be required concerning starting characteristics and sustained short-circuit current. Examples of such supplementary specifications are given in Appendix x to this manual.

Generating sets using prime movers other than RIC engines such as turbines are sometimes used. It should, however, be observed that in addition to high operating costs such generating sets will normally not be able to meet a start up time requirement of maximum 15 seconds.

ISO 8528, part 3, specifies the principal characteristics of a. c. generators when used for RIC engine driven generator set applications. It supplements the requirements specified in IEC 34-1. A synchronous a. c. generator should be selected and the rating class including a basic continuous rating based on duty type S1 (in accordance with IEC 34-1) should be specified.

The generating sets may be classified as Long-break sets, Short-break sets or No-break sets depending on the specified maximum start-up time. Short-break sets and No-break sets are provided with sources of stored mechanical energy to be used to supply power to the connected load for a short period of time and, where necessary, to start and accelerate the RIC engine.

The capacity of fuel and lubricating oil should be specified for a minimum running time without refuelling of not less than 24 hours. Refuelling should be planned with consideration to the fuel required for test operations included in the preventive maintenance programme.

3.2.2 **Independent power sources**

Commercial or public power supply

If a commercial or public power supply is used as secondary power supply to the visual and radio navigation aids the separation between the transmission lines for normal and secondary power supply should be at least 30 m for overhead lines and 6 m for underground cable.

Local power source

An aerodrome may have a power plant used for supply of electrical power to facilities other than visual and radio navigation aids. This power source may be considered an independent power source which may be used as a secondary power source for the visual and radio navigation aids. If the capacity of this local power source is limited automatic disconnection of some of the non-critical loads may be required before connecting this power source to the loads which are critical for visual and radio navigation aids.

3.3 SWITCH-OVER FROM PRIMARY TO SECONDARY POWER

3.3.1 **Definition of the "1 second switch-over time"**

3.3.2 **Methods of obtaining the required switch-over time**

3.3.3 **10 or 15 second switch-over time**

3.3.4 **1 second switch-over time**

3.3.4 **Uninterruptible power supply**

3.4 DISTRIBUTION OF POWER.

CHAPTER 4. ELECTRICAL CIRCUITS FOR AERODROME LIGHTING SYSTEMS

4.1 GENERAL

4.1.1 System characteristics

Aeronautical ground lights can be powered by either series or parallel circuits. Series circuits are normally used for aerodrome ground lighting systems. Such systems include most of the runway and taxiway lighting patterns and also the fixed approach lighting patterns.

Parallel (or multiple) circuits are normally used for apron floodlighting, sequence flashing approach lights, aerodromes with short non-instrument runways and special purpose visual aids such as wind direction indicator, aeronautical beacons and obstacle lights. Parallel circuits may be used also for approach, runway and taxiway lighting systems but series circuits are preferred both for technical and economical reasons. For code 2 and code 3 runways designed to support precision approaches the costs of the required lighting systems where parallel circuits are used will in many cases be three times as high as the costs of equivalent installations using series circuits. The main reason for this is that, unless very large conductor cross-sections are used, limitations have to be imposed on the length of the cables used for the parallel circuits due to the voltage drop in the circuit and necessary provisions for protection for safety.

4.1.2 Fundamental principles for the constant current circuits

The series circuit system is characterised by being supplied from a current controlled power source whereas the parallel circuit system is supplied from a voltage controlled power source.

The series circuit is supplied from a Constant Current Regulator — CCR — and all loads are connected in series. Light units are connected via isolating transformers. The CCR maintains a constant current independent of the load on the circuit (within the limits of the capacity of the CCR). The same constant current flows through all lamps connected to the circuit and there is no need to compensate for voltage drops in the leads. Thereby a uniform intensity of the lights connected to the circuit is assured. The intensity of the lights can be controlled over a wide range and the different subsystems can be operated at compatible intensities.

Since the current can be controlled at a low level (normally 6.6 A at the highest setting), a cable with a relatively small conductor cross-section can be used (normally in the order of 6 mm^2).

A typical series circuit is shown in figure xxx

Note.— There has long been a lack of international standards applicable to the series circuits. In 1994 the International Electrotechnical Committee — IEC — established Technical Committee No. 97 to prepare standards for electrical installations for lighting and beaconing of aerodromes. This manual refers to IEC standards applicable to the series circuits.

4.1.3 **Parallel circuits**

The term "parallel circuits" or "parallel system" is used in this manual to describe the multiple circuit system used for conventional type of electrical installations such as those of residential, commercial, public, industrial or agricultural premises. The circuits are supplied at nominal voltages up to and including 1 000 V a.c. or 1 500 V d.c. International standards for installations using parallel circuits are published in the IEC 364 standards. Electrical installations using "parallel circuits" shall conform to the national regulations for electrical installations in the respective country. In Europe and many other parts of the world, the IEC 364 standards have been adopted as the basis for the national regulations for electrical installations.

It is assumed that the users of this manual are familiar with parallel circuits and, therefore, the manual does not contain guidance on detailed design of parallel circuits.

4.2 DESIGN OF THE SERIES CIRCUIT

4.2.1 **Series circuit current**

The most common current ratings in use today are 6.6 A and 20 A (rms at rated maximum light intensity). Other current values have been used in the past. Standardisation is moving towards of 6.6 A as being the preferred international standard .

It is important to know that the losses in a series circuit cable at 6.6 A are about 11 per cent of those produced by the same series circuit operated at 20 A.

4.2.2 **Constant current regulators**

The constant current regulator (CCR) is the heart of the system, it maintains a constant current in the circuit regardless of the actual circuit load, input voltage and frequency variations. The characteristics of a Constant Current Regulator is shown in Fig. x.

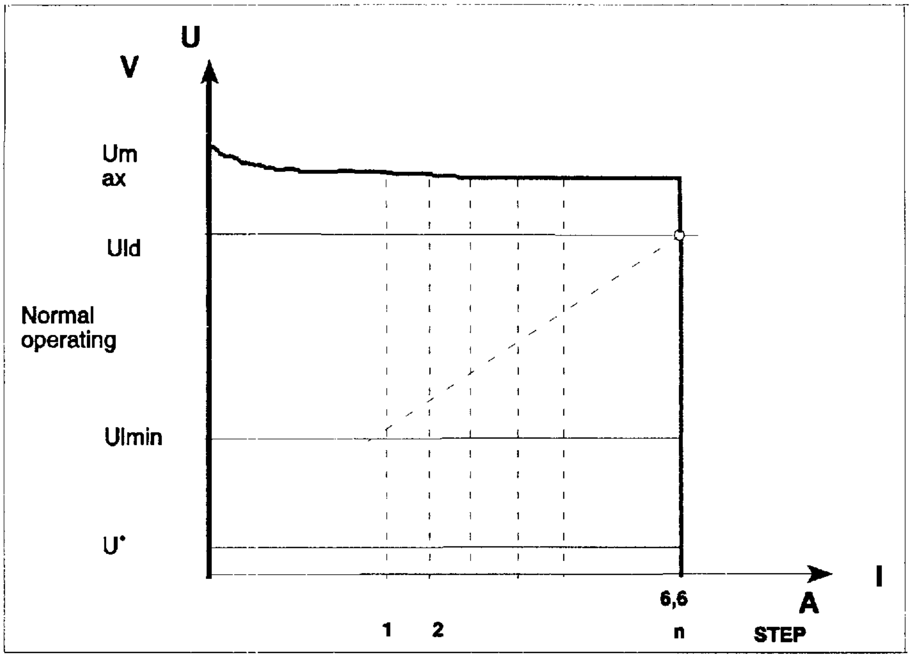

Fig. x. Operating characteristics of a constant current regulator

A detailed specification of the constant current regulator is published in IEC 1822.

Several types of CCRs are available on the market.

Thyristor regulators

The symmetrical phase control thyristor regulator is the most common type of CCR being installed today. The modular design allow flexibility in construction. The thyristor regulator unit is supplied from the mains input voltage and an output step-up transformer is connected between the regulator and the load. The step-up transformer should be provided with taps to allow adjustment of the output voltage to be compatible with the load requirements. The regulation performance is excellent. Harmonics generated by the regulator may have to be suppressed to meet the EMC requirements.

Pulse width modulation regulators

These regulators are based on a chopped DC voltage feeding a step up transformer. The regulators are connected to a three phase power supply facilitating a balanced distribution system. The power factor is high. The regulating characteristics are good. A built-in battery back-up can be provided creating an uninterruptible power supply to the lighting element powered by the regulator.

Transductor regulators

Current controlling transductors have long been used in battery charging equipment. In principle, a transductor element is a reactor provided with a special winding controlling the permeability of the iron core. CCRs using transductor elements are robust and simple devices and therefore very reliable. Regulating characteristics and power factor are not as good as for the thyristor regulators but are normally adequate for low power lighting circuits (a 5 kVA).

Resonant regulators

These regulators are based on a monocyclic square system including windings and capacitors to produce a constant output current. For the compensated types, an output current sensing regulates the output current of the resonant circuit. The regulators have good power factors. They are, however, not recommended for new installations due to their, large size and weight, poor output regulation against input voltage and frequency variations, and slow response time.

Moving coil regulators

An old CCR design is the "moving coil regulator". This type of regulator has separate primary and secondary coils which are free to move with respect to each other, thus varying the magnetic leakage reactance of the input and output circuits. The desired output current sets up a force of repulsion which floats the moving coil in a position which produces this current. A state of mechanical equilibrium is attained such that the force of repulsion balances the weight of the moving coil. Any change in load or input voltage is counteracted by movement of the floating coil to restore the mechanical/electrical balance. This type of regulator is no longer recommended for new installations mainly due to inadequate regulating characteristics and low power factor.

4.2.3 **Isolating transformers**

Isolating transformers are required to isolate the lamps from the primary circuit. Thus, an interruption in the lamp circuit will not interrupt the series circuit.

A detailed specification of the isolating transformer[4] is published in IEC 1823.

4.2.4 **Circuit selectors**

A device called "circuit selector" is sometimes used to switch loads connected to a CCR. As an example circuit selectors can be used for PAPI systems which only are operated for one landing direction at a time and a common CCR can be used for two different series circuits. Circuit selectors are also sometimes used for selective switching of taxiway lighting circuits.

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[4] The name "AGL series transformer" for this device has been proposed by IEC TC97.

4.2.5 Cables and connectors for series circuits

The cable used for the series circuit is normally a single core cable. For a 6.6 A circuit a nominal cross-section of 6 mm^2 is usually specified. The operating voltage to earth is dependent on the circuit load, but it is common practice to specify a nominal insulation of 5 kV. In a proposed European standard[5] two types of cables, rated 4 kV and 7 kV are specified. Concerning the need to specify shielded cables there are two schools of thoughts. Only shielded cables are specified in the proposed European standard.

4.2.6 Interleaving

Lighting elements which are essential for flight operations in runway visual range conditions less that 550 m should be interleaved over at least two circuits (clause 2.3 of this manual refers). Each circuit in an interleaved lighting element should extend throughout the whole of that element and be so arranged that a balanced symmetrical lighting pattern remains in the event of failure of one of the circuits. Runway centre line lights have to be interleaved in such a way that the colour coding of the system is not destroyed in case of failure of one of the interleaved circuits.

Examples of arrangements of interleaved runway and approach lighting circuits are shown in fig. xx

4.2.7 Earthing

The earthing system needs to be considered from several aspects. No system earthing is required for the constant current series circuit, with a possible exception for conductors used for signalling purposes.

[5] prEN 50213:1995

Three safety aspects have to be considered:

Aviation safety

Since interruption of service may result in hazardous situations in critical phases of aircraft movements high availability requirements have to be applied to the lighting systems. A single earth fault on the series circuit should not result in an interruption of services. The common practice is therefore to leave the primary circuit floating. It is, however, recommended that an earth fault monitoring system is provided.

Protection against electric shock

Unless required to meet EMC requirements no earthing arrangement for functioning purposes need to be provided. The earthing arrangement shall therefore primarily be designed to meet the safety requirements. The selection and erection of the equipment used in the earthing arrangement shall be such that

— the value of earthing resistance is in accordance with the protective requirements of the installation and expected to be continuously effective;

— earth-fault currents and earth-leakage currents can be carried without danger, particularly from thermal, thermo-mechanical and electro-mechanical stresses;and

— it is adequately robust and has additional mechanical protection appropriate to the assessed conditions of external influence.

Earthing conductors and electrodes shall be selected in accordance with appropriate electrotechnical standards such as IEC 364.

Exposed conductive parts of luminaires and supporting structures should be bonded to the protective earthing system.

In the case shielded cables are used in the primary circuit the shield should be connected the protective earthing system at both ends of the cable.

In apron areas an equipotential bonding system should be considered.

Protection against lightning strikes

For lightning protection of the cable network it is common practice to install a counterpoise wire approximately 15 cm above the primary cable. The counterpoise wire is normally a bare copper wire with a cross section of 25 mm^2 (or more). It is a common practice to bond the counterpoise wire to earth at intervals of approximately 300 m. In most cases there will be interconnections between the counterpoise and the protection earthing system. However, if it is desired to keep the two systems separated, bases and supports for the luminaires should be connected to the counterpoise.

Earthing requirements for cables used for signalling purposes are specified in relation to the specific applications. Special precaution may have to be taken when power cables are used for signalling purposes, particularly when the cables are brought into buildings or vaults.

4.3 ELECTRICAL INSTALLATION AT SMALL AERODROMES WITH NON-INSTRUMENT RUNWAYS

Whereas it is recommended and preferred to use the series supply for the runway lighting systems, parallel supply might also be used for the lighting of non-precision runways or heliports.

4.3.1 Series supply

For the series circuit details, refer to the above sections.

4.3.2 Parallel supply

As the fixtures are connected across the lighting circuit, a short-circuit will lead to an overload condition which will trip the protection and thus deactivate the whole circuit. It is therefore recommended to insert a protection fuse at all connection to the lighting circuit to prevent the total breakdown of the circuit in case of short-circuit in one of the luminaire. The intensity of the lights decreases with the line drop along the circuit, this may be misinterpreted if it is noticeable in a light pattern. Two conductors generally of large cross-section are required along the complete circuit, lamp filaments are larger and thus require larger optics and larger fittings. As far as possible, it is advisable to use a multiple phase power feeder and to balance the luminaires on the phases to reduce the voltage drop along the cable. On such installations, intensity adjustment is generally not provided to keep the investment cost as low as possible. The lighting control is simple and can just be a main circuit breaker or switch to apply the voltage on the power feeder.

4.4 FLASHING LIGHT SYSTEMS

The flashing light systems are generally powered from the mains voltage available in the substations. The supply from the low voltage switchboard uses a main feeder to the system central control cabinet. From this cabinet located within the flashing system, the power is distributed to the individual luminaires. Standard approach flashing systems include up to 30 luminaires and to reduce the voltage drops in the various power supply cables, a multiple phase supply is provided with balance of the luminaires over the phases. Every luminaire is equipped with an input protection device, either fuse or circuit breaker to prevent a complete system failure in case of failure of a single luminaire. The voltage is normally continuously applied on the power feeder in order to allow the anti-condensation heater to operate when the system is not in operation. Sometimes, the voltage is only applied on one of the phases to keep this heater operative and to activate the system, the power is applied on the other phase(s).

In some cases, and specially for small systems such as Threshold Identification Lights, the flashing lights can also be powered from a series circuit. In such cases, the units are connected to a series parallel adapter which convert the series current in a constant voltage. Sometimes, the systems may be controlled by sensing the actual current flowing in the series circuit. These adapters can not provide the heating power necessary to prevent condensation when the system is not operative. Note also that these adapters have a very low power factor at nominal series current and that the constant current regulators must be chosen according to such load. This type of supply should only be considered for small systems and parallel supply considered for complete sequence approach flashing systems.

4.5 FLOOD LIGHTING

Floodlights are used on all aerodromes to light up the apron areas. This lighting is necessary for all aprons, including isolated aircraft parking positions when they are intended for use at night to allow the aircraft servicing and to identify correctly the surface and obstacles. The floodlights are generally installed on top of masts to enable the correct light distribution over the lighted area. Depending on the occupation of the aircraft stands, it a common practice to control the operation of the floodlights, either by parking position or by mast. Therefore, the power supply will be adapted to cope with the lighting control requirements. Many floodlights are using discharge lamps which needs some time to reach their nominal light output. Therefore, to avoid long black out periods in case of power failure, in addition to these high performance luminaires, other luminaires using incandescent lamps are installed to provide a reduced lighting during the heating time of the discharge lamps. Once the high performance luminaires have reached their nominal operating characteristics, the incandescent luminaires can be switched off.

CHAPTER 5. CONTROL AND MONITORING SYSTEMS

5.1 GENERAL

The control and monitoring system (CMS) for visual aids should be considered as a part of the visual aids system which interfaces the ATC system. Therefore, its design and manufacture should fulfil the exacting requirements for availability and fail safe operation. Besides keeping the controllers workload to a reasonable level, the system should be a powerful tool for carrying out preventive maintenance of the aerodrome lighting system to enhance its availability.

The control and monitoring system should:

a) be in accordance with the requirements regarding light intensity control set out in Annex 14, Volume I and also be suitable in its general conception for any airport of any complexity or particular needs, and adaptable to changes in its physical characteristics (layout, installations, etc.) or in its procedures;

b) have a conception inspired by safety in such a way that allows for the redundancy of equipment or elements which would be critical for fail safe design;

c) have a high dependability; and

d) be capable of communicating with other related systems, as required.

The following description is of a general nature. It includes the functions and minimum requirements of a CMS, independent from any particular technical solutions. The particular design and detailing of each CMS should meet the individual needs of the airport which it is going to serve, and it should make the best use of the most up-to-date technology available.

5.2 MASTER CONTROL SYSTEM

5.2.1 Overview of the system

General

The design of the CMS should take into consideration the high requirements on availability and fail safe design. The system design should be modular and easily expandable. To obtain a high maintainability the system should be arranged in a structured way.

Additional requirements for systems based on microprocessors

Further to that seen previously in 5.2.1.1 it should fulfil the following:

a) the system should be provided with decentralised processing functions;

b) the communications between microprocessors should use error-checking protocols, in order to achieve high service integrity;

c) the software and hardware should be designed in a modular structure. The software should be written in a high level language so that it is adjustable to the needs of the application, that it be of extensive use and based on an appropriate operative system;

d) if information in the controller, maintenance or co-ordination workplaces is presented on a visual display unit, it should be of high resolution, with a sufficient refresh rate and luminance appropriate for the environment; and

e) the software should contain autodiagnosis routines to detect faults.

Overview diagram

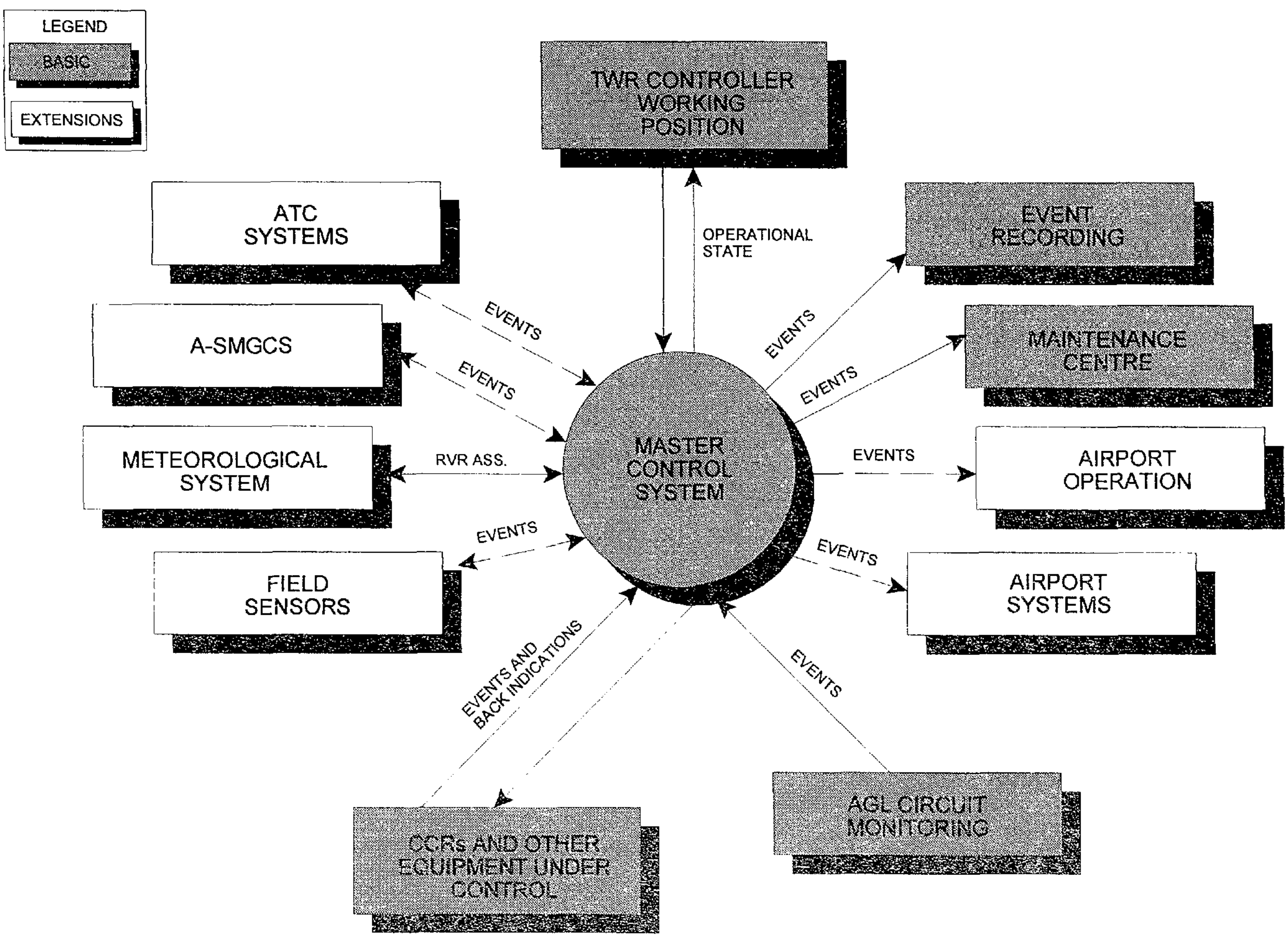


Figure x1 shows an overview of the system including the peripherals and interfaces with other related systems

The master control system (MCS) is found in the centre of the diagram. The CMS subsystems as well as other systems related to the CMS which are linked to the MCS are all found around this circle. The CMS subsystems which are considered basic are shown as shadowed boxes.

The arrows indicate the direction in which information flows, and on these, a brief description of the associated functions. The denominations *input* and *output* are given with respect to the MCS. The diagram doesn't include other possible or necessary connections between their own peripherals or other systems, which are not the subject of the description of the CMS.

The subsystems of a **basic CMS** are:

a) master control system (MCS), which provides the processing capabilities, accepts inputs and sends outputs, as appropriate, to other CMS subsystems;

b) human-machine interface (HMI) for the air traffic controller. This can not only be the controller in the tower, but also persons on the apron or in any other various positions at the airport where work is carried out, but with the capacity and authorization for working the airfield lighting. The HMI must give the controller the appropriate information;

c) maintenance centre HMI, for technical maintenance staff at the airport. If taken as an addition, the statistical data processing should be done in this workplace. The number and position of maintenance workplaces depends on the configuration and requirements of the airport;

d) Event recorder. This can be storage devices, printers, etc. which allow the storage of the functioning status information, and the date and time details of the alarms which occur in any event; and

e) interface with the CCR and other controlled equipment. Capable of transmitting the control signals, generated by the MCS, to the airfield lighting power and control units.

Depending on the configuration and requirement of the airport, the MCS may include all, or some of the following additional interfaces:

a) interface for the exchange of information with airport systems;

b) interface with the ATC system, for input commands (e.g. current information on CAT I, II, and III) and information exchange concerning the airfield lighting system;

c) interfaces for additional monitoring devices, for the supervision of the actual condition of the lighting system components (e.g. lamp condition monitoring, insulation monitoring, hour-meters, etc.);

d) interface for control signals from the field sensors (e.g. sensor signals for automatic stop bar control);

e) interface with the meteorological system, providing runway visual range (RVR) evaluation data exchange, which may allow the automatic/semi-automatic adjustment of the brightness of the visual aids; and

f) interface with the advanced surface movement guidance control system (A-SMGCS) for input commands (e.g. switching the taxiway centre line lights and stop bars) and status information from the visual aids system).

5.2.2 **Processing equipment**

General

The task of the command processing function is to co-ordinate all the input commands which come from the different workplaces, or external systems, giving corresponding priorities in each case and finally, producing the control signals for the CRCs and for other control units.

Every input command from the workplaces (HMI) should be confirmed with a acceptance signal of the input.

Figure 2, operating diagram, shows the processes of the CMS.

Operational status monitoring

The task of the monitoring function is to show the operating state and to detect faults in the airfield lighting system or in the CMS itself.

A fault is present if:

— there is a difference between the actual status of the airfield lighting system and the set status;

— a failure of a component or function is detected; or

— the result of some measurement is outside the permitted range.

If the system uses a database to register the information, it should be global, including the operational status so that alarms and faults register. Where appropriate the aforementioned database shall give an efficient exchange of information between the CMS and other system like the ASMGCS or the control and supervision of ATC systems and airports.

Alarm and event register

This should be used to record the corresponding times and dates of:

a) the input commands accepted and carried out by the system;

b) the operational conditions at each one of the subsystems;

c) the result from self diagnosis; and

d) information on anomalies, incidents and alarms, so as the system responses are the same.

Interface with CRCs and other supply control units

The function of this interface is to operate all devices which control the electrical supply from the different airfield lighting subsystems. It also collects the information required to verify the real operational conditions from the aforementioned devices.

System performance

Response times

The system response times should be suitable to meet the corresponding demands of the airport operations in the best times possible. Response times considered important are listed below.

a) time for command input to be accepted or rejected;

b) time from command input until command output, from devices, supply control, unit or airfield lighting;

c) time from input to the CCR (or other control units) until information is displayed in the tower;

d) change-over time of redundant systems in case of fault; and

e) automatic detection of faults in any part of the CMS.

Reliability

In the case of a severe fault in the CMS, the combined hardware design must ensure that the status of the airfield lighting system does not change automatically to a dangerous state. For the majority of airfield lighting subsystems, the brightness level should continue as it was before the failure. Some other systems, such as taxiway intersection lights, stop bars, taxiway centre line lights interlocked with a stop bar etc. must be left in a secure state, on or off.

In airports which require a high availability the system should have a redundancy design for the main components, i.e. the basics as seen in the diagram, figure 1

- central management system
- controller workplaces
- maintenance workplaces
- interfaces with the CRCs and other supply control units
- event register; and
- communication lines between these units.

5.2.3 **Human machine interface (HMI) subsystems**

Controller workplaces

The controller workplaces are the main HMIs of the system, conceived for controlling the airfield lighting and to display information concerning its current operational status and alarms.

The most important aims in its design are to keep the controllers workload at a reasonable level, to ease the correct input of commands and to give accurate status information. To fulfil these exacting requirements the HMI must provide exclusively the functions and information which are necessary for the traffic control purposes. In particular, all the functions for maintenance and all the detailed technical information must be addressed directly to the work places. The number and location of work places will depend on the configuration, and in general on the requirements of the airport.

Likewise, the work distribution and control transfers between different work places could be different for different airports.

If there is more then one workplace for one particular lighting subsystem the CMS will not accept simultaneous commands referred to the same subsystem (e.g. runway centre line and runway edges etc.). All work places (active or not) should display the exact status of the related airfield lighting systems.

Controller workplace command inputs

The basic requirement for the input interfaces are:

a) clear layout with large enough dimensions to allow simple and safe operation;

b) separate control elements for the "on"/"off" and brightness control adjustment for airfield lighting subsystems or subsystem groups;

c) control elements for selecting the direction of landing and take-off for each runway;

d) interface display test equipment;

e) element for acknowledging and resetting alarms;

f) panel illumination (or zonal illumination) which includes control illumination; and

g) option to include programmable commands (e.g. assigning taxi-way routing).

Information display at controller workplaces

Two basic requirements for the information display interfaces are:

a) to show the information concerning the operational status of the airfield lighting systems; and

b) for the alarms to indicate by acoustic alarms and flashing lights.

Maintenance centre

The workplace should give maintenance personnel access to all detailed technical information of the airfield lighting system besides supplying actual operational state and alarm information. In particular, if additional monitoring devices (e.g. the lamp failure monitors or the insulation monitors) the given results and alarm should be shown directly in this workplace.

5.2.4 **Communications network**

The communications within the system are made at several levels. The following presents a set of examples:

a) *HMI-processors*
If the HMI's are mere terminals of the processors, this connection could be made by means of a serial line (RS-232/422). If the distance between HMI's and processors is large enough, this connection should be made with fibre optics.

b) *Processors — I/O processor*
This communication could be made through either the communication bus or a serial line RS-232.

c) *Processors — other equipment*
The control system should have available the most usual means (RS-232 serial line, Ethernet network, ...) to allow for its connection with other equipment, such as the light failures monitoring system, meteorological system, A-SMGCS, CRCs and other control units.

d) *I/O processor — CRCs and other control units*
Each processor output is connected to the corresponding units. There will be the appropriate feedback to the I/O processor, to allow to check out that the command has been fulfilled.

5.3 LIGHT INTENSITY CONTROL

Regarding the light intensity control of visual aids, it is established as a standard in Annex 14, Volume I, that

> "*where a high-intensity lighting system is provided, a suitable intensity control shall be incorporated to allow for adjustment of the light intensity to meet the prevailing conditions. Separate intensity controls or other suitable methods shall be provided to ensure that the following systems, when installed, can be operated at compatible intensities:*
>
> — *approach lighting system;*
> — *runway edge lights;*
> — *runway threshold lights;*
> — *runway end lights;*
> — *runway centre line lights;*
> — *runway touchdown zone lights; and*
> — *taxiway centre line lights.*"

Similarly, some specific texts related to heliports, either Notes or SARP's, can be found in Annex 14, Volume II, referring to the most important heliport visual aids (e.g. visual approach slope indicator, visual alignment guidance system, approach lighting system, ...)

Annex 14, Volume I, Attachment A as well as the *Aerodrome Design Manual*, Part 4 — *Visual Aids* (Doc. 9157) provide valuable guidance material on light intensity control and settings.

To meet the above mentioned Annex 14, Volume I standard on compatible light intensities, an excellent way is to provide either:

a) an interface of the MCS with the meteorological system, which will allow the automatic or semiautomatic adjustment of the brightness of the airfield lighting (see 5.2.1.3, additional interfaces, subparagraph (e)); or/and

b) HMIs, especially the controller workplaces, with functional keys. These keys, arranged in groups related to background luminance and prevailing visibility conditions, will produce global commands, affecting various systems in a consistent way, thus operating them at relative light intensities that are duly adapted to the same purpose.

5.4 CONTROL OF POWER SUPPLY AND DISTRIBUTION SYSTEMS

CHAPTER 6. SURFACE MOVEMENT GUIDANCE AND CONTROL SYSTEMS

CHAPTER 7. LAMPS AND LUMINAIRES

7.1 GENERAL

Photometric performance requirements for aeronautical ground lights (AGL) are specified in Annex 14, Volume I, Appendix 2.

The light is radiated by lamps installed in luminaires. The IEC definition of the term "luminaire" can be found in subclause 1.5.2.

7.2 LUMINAIRES

Specifications of aerodrome luminaires are published[6] in:

IEC 1824	Flashing lights used on airports
IEC 1825	Fixed and flashing lights used for obstacles
IEC 1826-1	Inset luminaires used on airports — Part 1: Bases and connections
IEC 1826-2	Inset luminaires used on airports — Part 2: Characteristics of inset light
IEC 1827	Elevated luminaires used on airports

7.3 LAMPS

7.3.1 General

Approach, runway (edge, threshold, runway end, centre line and touch-down zone) and taxiway (edge and centre line) lights need to have adjustable intensities so that the intensities can be set at compatible levels as required by the prevailing visibility and ambient light conditions. Therefore, Standard AGL lamps currently available on the market are incandescent lamps (including tungsten halogen lamps).

7.3.2 Incandescent lamps

The traditional incandescent lamp would be an ideal light source if it had not been for its short useful life and low luminous efficacy. The luminous efficacy of a standard incandescent lamp is approximately 10 $lm*W^{-1}$. The characteristics of the incandescent lamp are depending on the temperature of the filament. The visible effect of a change in filament temperature is a change in the colour of the light. The operating temperature of a standard incandescent lamp is about 2 500 K and the design lamp life is about 1 000 h. The operating temperature of a photo-flood lamp is about 3 400 K but the expected lamp life is reduce to about 20 h. For use in contemporary AGL luminaires the standard incandescent lamps has been replaced by halogen lamps.

[6] The publications are in preparation

7.3.3 Halogen lamps

In principle, a halogen lamp is similar to a standard incandescent lamp. The main difference is that a regeneration process is employed in the halogen lamp. A halogen[7] gas is added to the standard nitrogen and argon mixture in the bulb. Evaporated tungsten particles are caught in a chemical combination with the halogen gas. When such a molecule randomly moves in the vicinity of the heated filament the combination is dissolved and the tungsten particle is returned to the filament. It is not exactly a self-healing process but an extended lamp life is achieved and blackening of the bulb is reduced. The regeneration process requires a gas temperature above 260 ^{0}C and relatively small bulbs made of quartz glass are needed. Lamp lives in the range 2000 to 4000 h can be expected depending on the service conditions. The luminous efficacy is about 20 $lm*W^{-1}$ and the colour temperature about 3 000 K (similar to the photo-flood lamps). Halogen lamps are supplied from extra low voltage sources (< 50 V) and the filament is normally wired in a "double-spiralled" coil. In this way a relatively concentrated lighting surface is achieved which benefit the optical design of the luminaire.

7.3.4 Discharge lamps

Special types of discharge lamps are used for flashing lights.

7.3.5 Fluorescent lamps

Fluorescent lamps are not normally used in AGL systems, with the exception of transilluminated (internally illuminated) signs. The light emitting medium in the fluorescent lamps is mercury vapour. The tube is filled with a gas consisting of argon or krypton and a small amount of mercury. The emitted light is in the UV range and is converted to visible light by a fluorescent medium (a powder inside the tube). The luminous efficacy is in the range 80 to 100 $lm*W^{-1}$, lamp lives in the order of 16 000 h are being advertised and it is understandable why the fluorescent lamps are widely used in signs. However, designers should be aware of some of the limitations, particularly when used in low temperatures.

The light emission is dependent on the gas pressure inside the tube. The design values are a pressure of 0.8 Pa and a temperature of 40°C, which is normally achieved at an ambient temperature in the range 20 to 25°C. At low temperatures the gas pressure decreases and also the amount of mercury atoms available for the light emission. The light output from most fluorescent lamps drops dramatically when the ambient temperature drops below approximately -5°C. The efficacy in low temperatures is dependent of the design of the lamp and on how the lamp is erected inside the sign but without special arrangements a standard fluorescent lamp will have its light output reduced to less than 20 per cent of the rated value at an ambient temperature of -20°C.

Using modern electronic control gear fluorescent lamps can be operated using a 12 or 24 V battery supply. Normal fluorescent lamps are provided with preheated electrodes. Tubes without preheating ("cold cathode tubes" and neon tubes) need a high voltage (often > 1 V) to get started but are claimed to have a very long useful life. It should, however, be observed that the difficulties in achieving the

[7] Halogen is a collective term for the elements bromide, iodide, chloride and fluoride. Bromide is the most common element used in halogen lamps.

necessary amount of current carrying mercury vapour in low temperature are more pronounced in cold cathode tubes.

The type of lamp must be carefully selected and florescent lamps are not recommended for use in service conditions below -20°C.

7.3.6 Induction and microwave lamps

It is anticipated the induction and microwave lamps suitable for use in AGL luminaires will be developed in the future. Such lamps will be dealt with in future editions of this manual.

7.3.7 Lamp life

Incandescent lamps (including halogen lamps)

The rated lamp life should be the "average life" (as defined in sub-paragraph 1.5.2) determined from a life test and be the calculated mean life of a sample of 10 lamps installed in luminaires mounted so that specified service conditions can be simulated. The resulting value may be rounded to the nearest 50 h.

Unfortunately, there is no international standard for determination of lamp life for lamps used in AGL systems. Stated lamp lives in catalogues are based on tests in open racks and the lamps supplied from a constant voltage source. It should be observed that the service conditions in aerodrome environments are quite different. It is important that AGL lamps are tested using a constant current source.

A life test should continue until 90 per cent of all lamps have reached the end of useful light output, which is normally considered to be 80 per cent of the initial light output (in lumens). It should be observed that halogen lamps supplied from a constant current source will normally not die suddenly (as is normally the case with the lamps supplied from a constant voltage source) but rather fade out very slowly.

Fluorescent lamps

The average life of a fluorescent lamp is normally determined as the time until the light output has dropped to 80 per cent of the 100 h light output (in lumens). This means that the lamp should be operated 100 h before the life test starts. Catalogue values of standard fluorescent lamps are (tested as defined above) are normally in the order of 9 000 h. It should, however, be observed that the use of electronic (high frequency) control gear will result in considerably longer lamp life (in the order of 16 000 h or better).

7.3.8 Power consumption

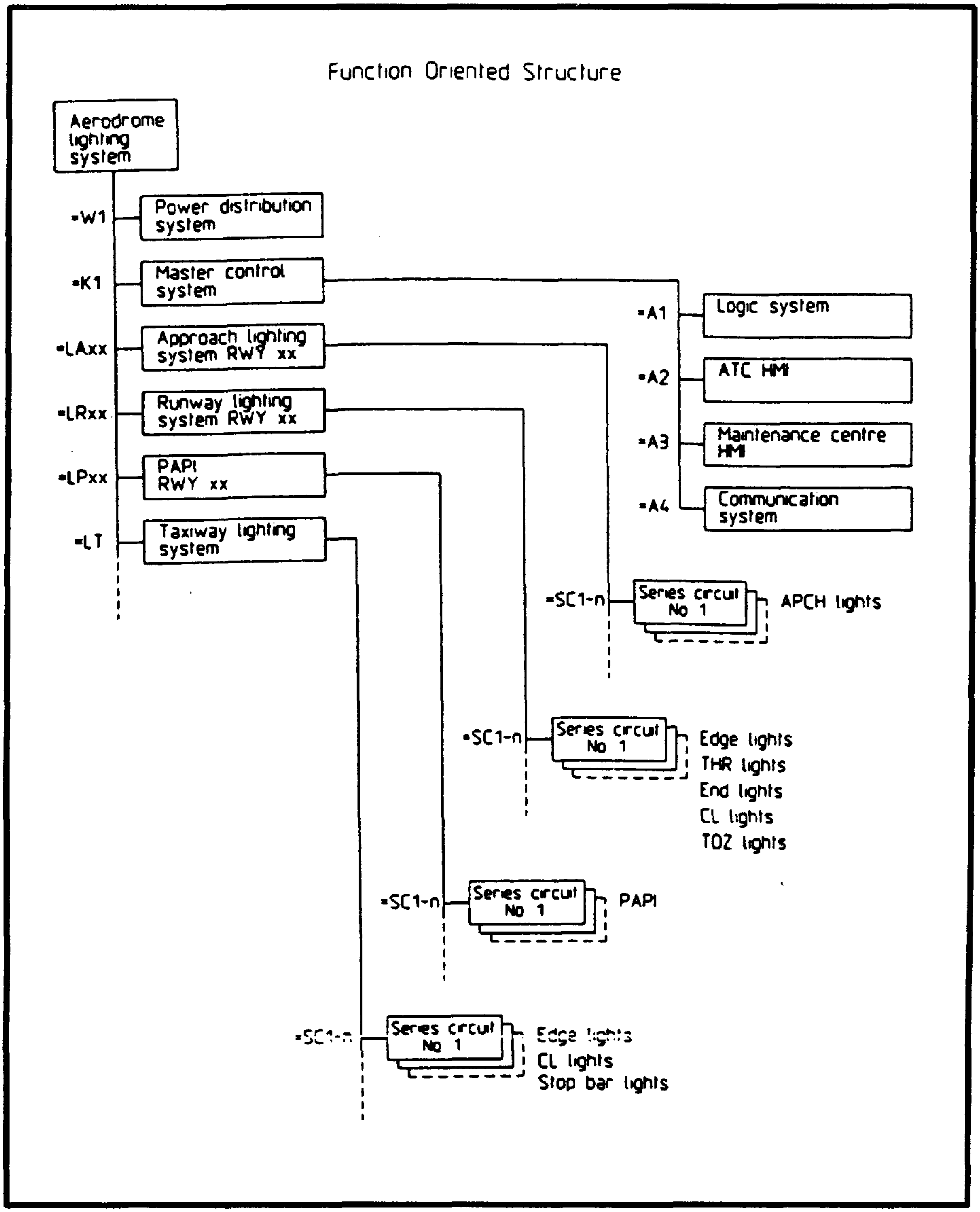
When calculating the power requirements for an AGL light unit it is necessary to take into account not only the lamp it self but also the losses in ballasts, control gear and supply cables in related to the luminaires.

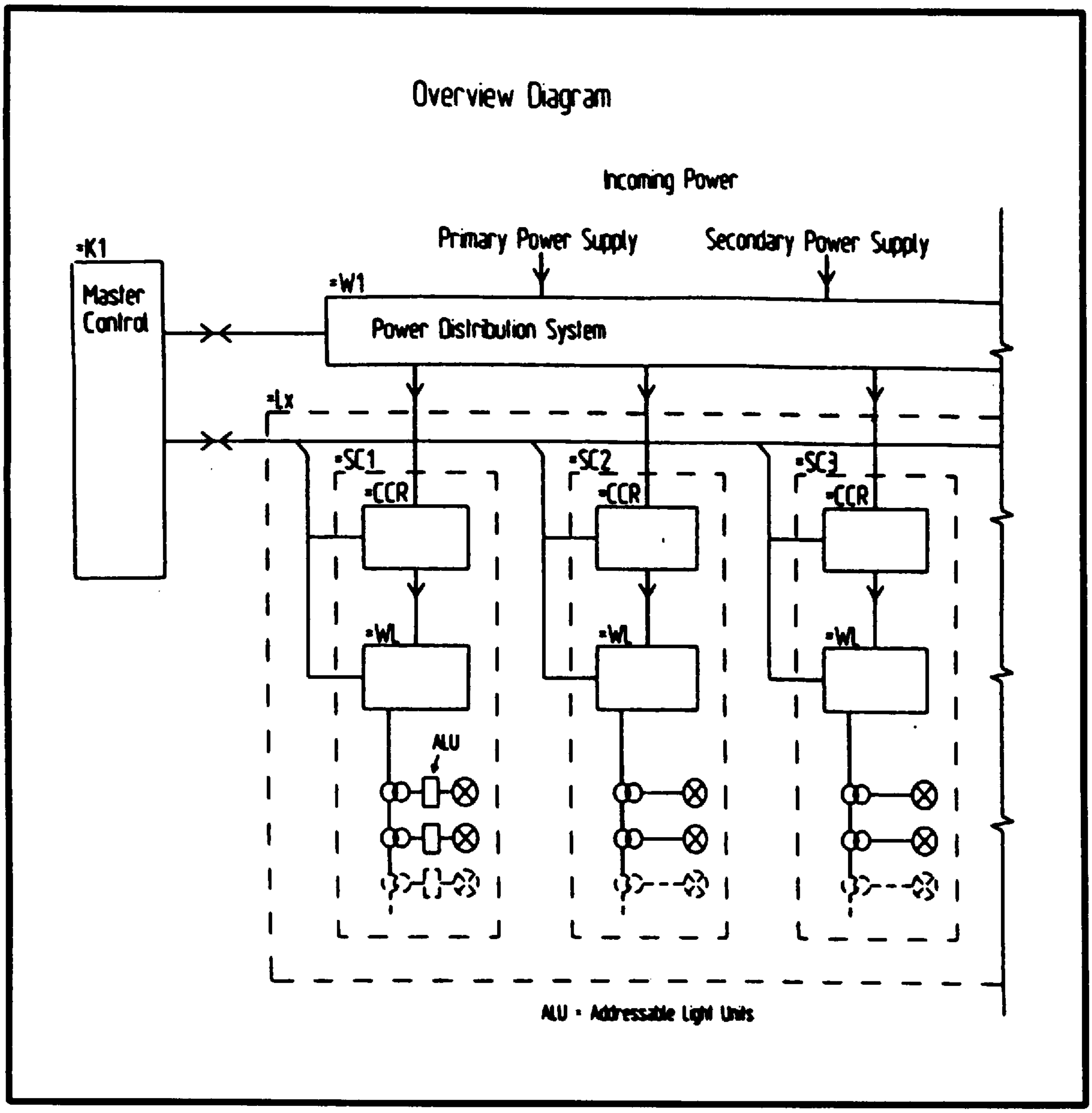
7.3.9 Lamp disposal

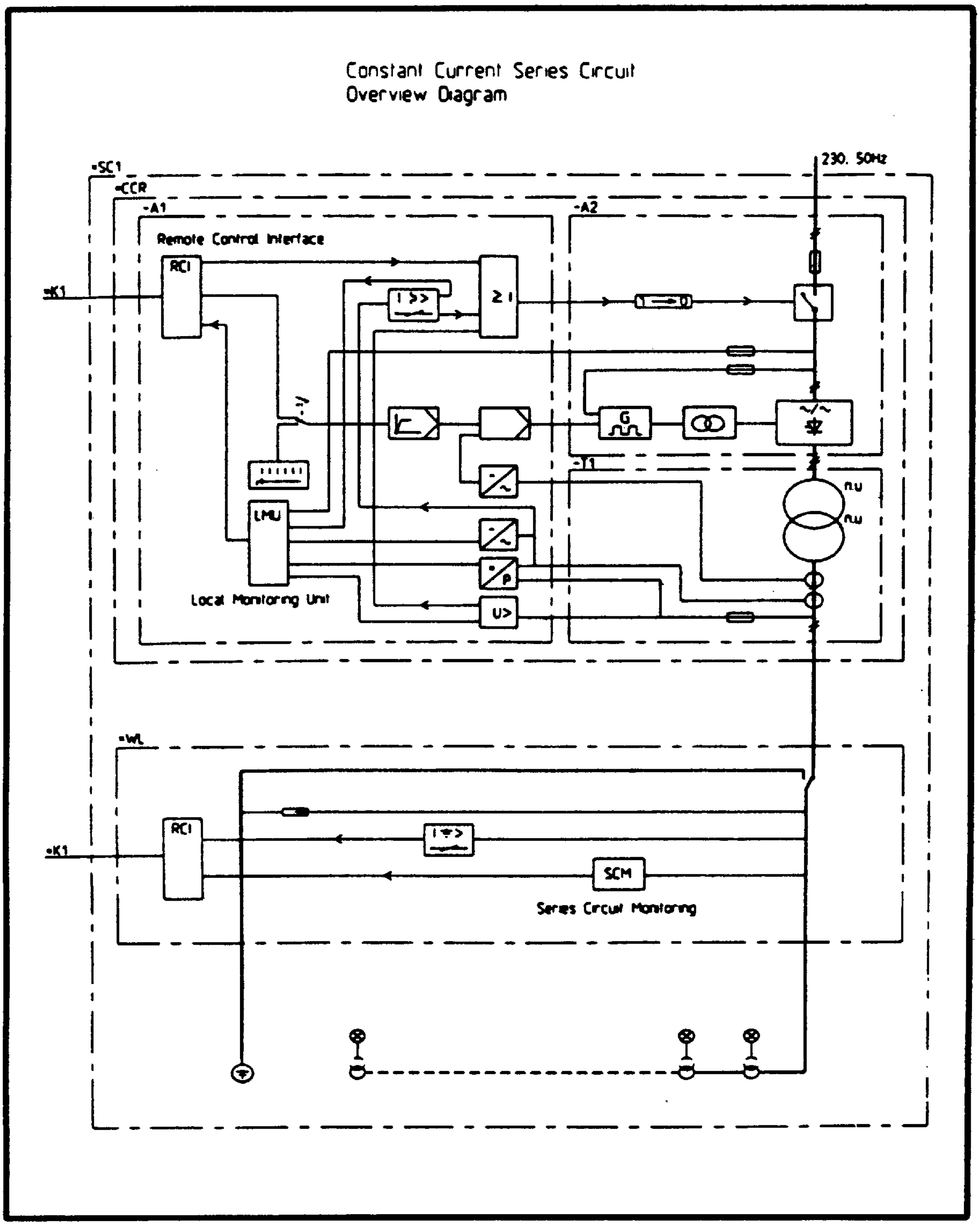
Being environmentally conscious the airport management should have a plan for disposal av replaced lamps. In particular, mercury is considered a hazardous heavy metal and therefore lamp containing mercury (such as fluorescent lamps) need special considerations in the disposal phase. The environmental aspects need also be considered in the design phase of the AGL system.

ATTACHMENT A

Examples of a function oriented documentation structure and overview diagrams for AGL electrical systems conforming to IEC documentation standards




Overview Diagram
Incoming Power
Primary Power Supply
Secondary Power Supply
*K1
Master Control
*W1
Power Distribution System
*Lx
*SC1
*SC2
*SC3
*CCR
*WL
ALU
ALU = Addressable Light Units


Constant Current Series Circuit
Overview Diagram
230, 50Hz
-SC1
-CCR
-A1
-A2
Remote Control Interface
RCI
-K1
I >>
≥ 1
G
-T1
LMU
U>
Local Monitoring Unit
-WL
RCI
-K1
SCM
Series Circuit Monitoring

PART II — REPORT ON AGENDA ITEM 3

Agenda Item 3: Obstacle lighting

3.1 INTRODUCTION

3.1.1 The purpose of this agenda item was to review and update the current Annex 14, Volume I specifications on obstacle lighting with the view to:

a) ensuring that the specifications include lights appropriate for different visibility and operating conditions; and

b) overcoming the environmental problems with the use of flashing lights at night, particularly the high-intensity flashing-white obstacle lights.

3.1.2 At VAP/11, the panel agreed that it would be beneficial to review and update the specifications on obstacle lighting taking into account recent advances on the subject. Thus, the panel agreed to recommend to the Air Navigation Commission that an appropriate item be added to the work programme. The Commission approved this recommendation and added an item entitled "Obstacle lighting" to the panel's work programme.

3.1.3 The VAP/12 Meeting took into account the environmental problems associated with the use of flashing-white obstacle lights by night, when developing specifications for a medium-intensity flashing-white obstacle light and updating the current specifications for high-intensity flashing-white obstacle lights. The principal advantage of installing medium-intensity flashing-white lights on towers is that there will be no need to display paint markings on them for day recognition. However, both medium-intensity and high-intensity obstacle lights have been reported to cause problems by night. As a means of overcoming this problem, the VAP/12 Meeting agreed to specify a dual-lighting system, composed of medium-intensity flashing-white lights for day use, and steady-red lights for night use. Although the envisaged dual-lighting system would help to overcome the environmental problems, there were indications from the comments received from States and international organizations on the proposed amendments to Annex 14, Volume I, that the photometric characteristics envisaged for the lights in the proposed Table 6-2 could not be met.

3.1.4 As regards the high-intensity flashing-white obstacle lights, the VAP/12 Meeting agreed to recommend a substantially lower intensity for night use. However, it was clear from the experiences in the United Kingdom that the envisaged reduction in intensity alone would not help to overcome the objections to the use of such lights by night. In view of this, the Secretariat examined, in consultation with the VAP members, whether the photometric characteristics specified by Canada or the United States for medium-intensity flashing-white obstacle lights could be incorporated into the proposed Table 6-2, in lieu of those recommended by the VAP/12 Meeting. These discussions revealed that the very concept of using flashing-white obstacle lights should be subjected to a critical examination before consideration was given to establishing specifications for a medium-intensity flashing-white obstacle light.

3.1.5 The above examination also brought to light other shortcomings in the amendments formulated by the VAP/12 Meeting. For example, it appeared illogical to increase the intensity currently specified for the medium-intensity flashing-red obstacle light from 1 600 cd (effective) to

20 000 ± 25% cd (effective) or to introduce specifications for a new medium-intensity steady-red obstacle light with an intensity of 20 000 ± 25% cd, as proposed by the VAP/12 Meeting. Also, the tests carried out in the United Kingdom after the VAP/12 Meeting had indicated that the obstacle light specified in Annex 14, Volume I, paragraph 6.3.12, was not suitable for use on follow-me vehicles and that an obstacle light of higher intensity should be developed for use on such vehicles.

3.1.6 In light of the foregoing, the following course of action was proposed by the Secretariat for consideration by the ANC:

a) the specifications proposed by the VAP/12 Meeting for new medium-intensity flashing-white and medium-intensity steady-red obstacle lights be deleted from the amendment proposal;

b) the effective intensity of the currently specified medium-intensity flashing-red obstacle light be not increased from 1 600 cd to 20 000 ± 25% cd as proposed by the VAP/12 Meeting;

c) the proposed Table 6-2, showing the photometric characteristics of obstacle lights, be deleted from the amendment proposal. However, the lower intensities proposed by the meeting for high-intensity flashing-white obstacle lights for luminance values less than 50 cd/m^2 be incorporated into Annex 14, Volume I to minimize the environmental problems associated with the use of those lights by night;

d) the specifications proposed by the VAP/12 Meeting for obstacle lights to be displayed on vehicles be expanded to include a new light of higher intensity for use on follow-me vehicles;

e) the proposed Attachment C, Figures C-1 and C-2 showing the arrangement of obstacle lights be deleted from the amendment proposal; and

f) VAP be invited to review and update the Annex 14, Volume I specifications on obstacle lighting, as necessary, taking into account the environmental problems associated with the use of flashing-white obstacle lights by night.

3.1.7 During its final review of the proposals for amendment of Annex 14, Volumes I and II, the ANC endorsed the proposed course and agreed to revise the description of work programme Item 4 — Obstacle lighting, to include a review of all types of obstacle lighting, i.e. low-, medium- and high-intensity lights. The remaining amendments related to obstacle lighting formulated by the VAP/12 Meeting were incorporated into Amendment 1 to Annex 14, Volume I adopted by the Council on 13 March 1995.

3.1.8 Since the VAP/12 Meeting, the panel has had four rounds of correspondence on the subject, *viz.* VAP-Memos/376, 383, 390 and 391. Assistance in progressing work has also been received from the VAP Working Group on Visual Aids for SMGC and working papers related to obstacle lighting were presented at the Toulouse, Boston, Tokyo, Amsterdam and Montreal meetings of the working group. As a result, a proposal for amendment to Annex 14, Volume I was developed for review by the meeting.

3.2 RATIONALE FOR OBSTRUCTION LIGHT INTENSITIES

3.2.1 The United States rationale for the definition of obstacle light intensity is reflected in Table 1 below depicting the distances from which various obstruction light intensities can be seen under 1 and 3 statute miles meteorological visibilities:

Table 1

Time period	Meteorological visibility (statute miles)	Distance (statute miles)	Intensities (candelas)
Day	1 (1.6 km)	1.5 (2.4 km) 1.4 (2.2 km) 1.0 (1.6 km)	200 000 ±25% 100 000 ±25% 20 000 ±25%
Day	3 (4.8 km)	3.0 (4.8 km) 2.7 (4.3 km) 1.8 (2.9 km)	200 000 ±25% 100 000 ±25% 20 000 ±25%
Twilight	1 (1.6 km)	1.0 (1.6 km) to 1.5 (2.4 km)	20 000[1)] ±25%
Twilight	3 (4.8 km)	1.8 (2.9 km) to 4.2 (6.7 km)	20 000[1)] ±25%
Night	1 (1.6 km)	1.1 (1.8 km) 1.2 (1.9 km) 0.6 (1.0 km)	1 500 ±25% 2 000 ±25% 32 ±25 %
Night	3 (4.8 km)	2.9 (4.7 km) 3.1 (4.9 km) 1.4 (2.2 km)	1 500 ±25% 2 000 ±25% 32 ±25%

[1)] Distance calculated for north sky illuminance

3.2.2 In conclusion, pilots of aircraft travelling at 165 kt (190 mph/306 kph) or less should be able to see obstruction lights in sufficient time to avoid the structure by at least 610 m (2 000 ft) horizontally under all conditions of operation. Pilots operating between 165 kt and 250 kt (288 mph/463 kph) should be able to see the obstruction lights at 1.9 km (1.2 miles), unless the weather deteriorates to 1 statute mile visibility at night during which time period 2 000 cd would be required to see the lights at the same distance. A higher intensity with 3 statute miles visibility at night could generate a residential annoyance factor. In addition, aircraft in these speed ranges can normally be expected to operate under instrument flight rules (IFR) at night when the visibility is 1 statute mile.

3.2.3 In the United Kingdom, the rationale for the definition of obstacle light intensity is based on the assumption that lights should have a range equal to the lowest visibility in which one can fly VFR, i.e. 3.7 km. This requires a daytime intensity of approximately 200 000 candelas.

3.3 ENVIRONMENTAL EFFECTS OF FLASHING LIGHTS AT NIGHT

3.3.1 Environmental problems with the use of obstacle lighting have been identified. The problem is dependent on the location of the towers. Certain areas are more sensitive to environmental concerns. Such areas include suburban areas, national parks, valleys, and where lights are located on buildings of historic or architectural significance. The issue will have to be examined from several perspectives. The light characteristics which, in combination, can produce the subjective difference between "environmentally objectionable" and "environmentally unobjectionable" include:

a) colour;

b) intensity in the direction of the viewer, i.e. ground illumination;

c) flashing vs. non-flashing;

d) flash rate;

e) flash duration; and

f) lighting pattern (configuration) on the structure.

3.3.2 The intensity of light in the direction of the viewer is a major contributor to the environmental acceptability of flashing-white obstacle lights at night. The amount of ground illumination (assuming the observer is at the same elevation of the base of the tower) is determined by several factors including:

a) optical design, i.e. beam pattern;

b) height of the light fixture above ground level (AGL);

c) horizontal distance from the obstacle to the viewer;

d) meteorological visibility conditions, i.e. transmissivity of the atmosphere; and

e) in the case of high-intensity lights, vertical aiming adjustments to the light fixture.

3.3.3 The environmental acceptability of various colours of light is very subjective. However, it is generally agreed that, for whatever reasons, aviation red obstacle lights are less objectionable to persons at ground level than flashing-white obstacle lights.

3.3.4 The United States has recently allowed medium-intensity flashing-white obstacle lights at night to have the same longer flash duration as red obstacle lights (up to 2/3 of the flash period). Over a period of time, data will be gathered on the environmental acceptability of this option.

3.4 EVALUATIONS SINCE THE VAP/12 MEETING

3.4.1 Since the VAP/12 Meeting, a trial was carried out in the United Kingdom on obstacle lights. The more significant recommendations stemming from this trial are as follows:

a) high-intensity flashing-white obstacle lights perform adequately by day;

b) flashing lights, either red or white, should not be used for the night lighting of obstacles where such lights may cause significant environmental concern;

c) for lighting of en-route obstacles by night, 2 000 cd omnidirectional steady-burning red lights spaced at intervals not exceeding 50 m should be adopted;

d) the use of 600 cd steady-red lights in rural environments should be investigated; and

e) the use of high-intensity flashing-white obstacle lights (by day only) mounted on or near the ground should be investigated.

3.4.2 In a subsequent trial, the proposal at 3.4.1 e) was evaluated. The trial showed that:

a) in many circumstances no lighting is needed, since the unlit mast is clearly visible before the light and at sufficient ranges for safe operations;

b) occasionally in bright day conditions with the sun behind the pilot, the light is seen before the mast in which situation only the light gives sufficient range;

c) particularly in the case described at 3.4.2 b) pilots prefer a pattern of lights to clearly delineate the mast; and

d) there is a requirement for a system that can be seen at elevations below the bottom of the mast to safeguard operations where the mast is on a small hill or escarpment and where the aircraft may be flying at a height below the bottom of the mast.

3.4.3 Furthermore, an additional study in the United Kingdom on medium-intensity obstacle lights concluded that it would be impracticable to develop a light conforming to the specifications agreed to at the VAP/12 Meeting for the proposed new medium-intensity flashing-white obstacle lights (paragraph 3.1.3 above refers). The result of the study also indicated that the envisaged beam spreads would further aggravate the concerns associated with the use of flashing-white lights by night. A comparison of the VAP/12 specifications for the new medium-intensity flashing-white obstacle lights with those used in Canada and the United States confirmed that the United Kingdom conclusions were well-founded.

3.5 DISCUSSION

3.5.1 In the United Kingdom both medium- and high-intensity flashing-white lights continue to cause problems by night. The United Kingdom proposes to overcome the problem through the sole use of steady-red lights at night. For night use, 2 000 cd steady-red lights have been found acceptable. For daytime recognition, an effective intensity of 200 000 cd in white may be needed. The United Kingdom will continue to study these issues, since it was considered that trials had not produced a final solution for day and night operations that was both effective and practicable.

3.5.2 In the United States, the number of 45 m high antennas is increasing rapidly primarily as a result of the expansion of cellular communications. In order to receive a determination of "no hazard" from the FAA, they will have to be marked and/or lighted in accordance with the recommendations contained in that determination. Any failure or malfunction of more than a thirty-minute duration, which affects a top light or any flashing obstruction light regardless of its position, should be reported to the FAA immediately so that a NOTAM can be issued. If such towers are lighted by flashing-red obstruction lights by night, they must also be marked for daytime and twilight conditions.

3.5.3 The United States sees the need to include specifications for a medium-intensity flashing-white obstacle light in Annex 14, Volume I. A considerable cost savings can be achieved through the use of medium-intensity flashing-white obstacle lights in lieu of marking by day and twilight and in lieu of flashing-red lights by night. In this context, it was noted that an evaluation conducted in the United States concluded that, except for down sun conditions (the sun behind the object), the 20 000 cd strobe lighting system is more effective than paint for marking short skeletal towers of 153 m (500 ft) or less. With respect to down sun conditions, strobe lighting is more effective up to 1 mile from the tower and essentially equally as effective between 1 and 2 miles. Greater than 2 miles from the tower painting is more effective. Furthermore, the effective intensities and beam spreads specified by the United States for medium-intensity flashing-white obstacle lights have been found to be appropriate. In fact, no aircraft has collided with any tower marked by medium-intensity flashing-white lights. The Canadian experience also seemed to attest to the appropriateness of the United States specifications. In the past fifteen years, just two tower strikes had taken place in Canada and both by day.

3.5.4 The United States also sees the need to include specifications for dual-lighting systems in Annex 14, Volume I. The United States provides specifications for such systems which include red lights used for night-time and high- or medium-intensity white lights for daytime or twilight time. These lighting systems may be recommended when an aeronautical study determines that it is not feasible to operate a high- or medium-intensity white lighting system at night. When high-intensity white lights are operated during daytime and twilight, other methods of marking may be omitted. When medium-intensity white lights on structures 153 m (500 ft) or less above ground level are operated during daytime or twilight, other methods of marking may be omitted.

3.5.5 One panel member in his response to VAP-Memo/383 had advised that he was hesitant to propose a reduction in light intensities for environmental reasons on a general basis and had suggested that Annex 14, Volume I should specify alternative obstacle lighting systems to be decided at the discretion of the individual State.

3.5.6 At its eleventh meeting, the VAP Working Group on Visual Aids for SMGC conducted a final review of the current provisions in Annex 14, Volume I for denoting obstacles in light of the evaluations performed since VAP/12 as well as current practices in States. The working group concluded that:

a) the subjective difference between "environmentally objectionable" and "environmentally unobjectionable" obstacle lighting systems depended largely on the photometric characteristics of the lights;

b) the intensity of light in the direction of the viewer was a major contributor to the environmental acceptability of flashing-white obstacle lights at night;

c) aviation-red obstacle lights at night were less objectionable to persons at ground level than flashing-white obstacle lights;

d) several complex factors affected the individual's perception of different obstacle lighting systems;

e) reduction in light intensities for environmental reasons alone was not acceptable; and

f) it would not seem practicable to develop Standards or Recommended Practices for a single type of obstacle lighting system for all conceivable situations.

3.5.7 In view of the above conclusions, the working group had agreed that it would be appropriate to specify alternative obstacle lighting systems to be decided at the discretion of the individual State. On this basis, the salient features of the proposed amendment to Annex 14, Volume I included the following:

a) Incorporation of specifications for three types of medium-intensity obstacle lights replacing the currently specified medium-intensity flashing-red obstacle light designated as follows:

Type A — Medium-intensity flashing-white light
Type B — Medium-intensity flashing-red light
Type C — Medium-intensity steady-red light

b) Incorporation of specifications for dual obstacle lighting systems to be used where high-intensity obstacle light, Type A or B, or a medium-intensity obstacle light, Type A, at night may dazzle pilots in the vicinity of an aerodrome (within an approximate 10 000 m radius) or cause significant environmental concern. These dual obstacle lighting systems included red lights to be used during night-time and high- or medium-intensity white lights, as appropriate, to be used during daytime or twilight time.

c) Redesignation of the currently specified low-intensity red light as Type A. Incorporation of specifications for an additional type of low-intensity red light, Type B, to be used in combination with medium-intensity flashing-red obstacle lights, Type B.

d) Incorporation of a new Table 6-2 including light characteristics of obstacle lights. These characteristics were incorporated as a Standard. In developing this table, care had been given to limit the downwards intensity of obstacle lights as far as practicable.

e) Recommendations on how a combination of low-, medium-, and/or high-intensity obstacle lights should be displayed (see proposed new Appendix 6 to Annex 14, Volume I).

3.5.8 In this context, the working group had pointed out that the proposed new medium-intensity red lighting systems and the high-intensity flashing-white lighting systems had proven equally effective at night.

3.5.9 The working group had also pointed out that, since the proposed new Table 6-2 also included light characteristics for follow-me vehicles and other vehicles, such as emergency and security vehicles, to avoid duplication of information it would be appropriate to delete Sections 13.2 and 13.3 of Annex 14, Volume I, Attachment A.

3.5.10 The meeting agreed to the conclusion of the working group related to the application of different types of obstacle lighting systems. The meeting also endorsed, in principle, the related proposal for amendment of Annex 14, Volume I. However, it considered that further refinement of the proposed new Table 6-2 as well as the development of a new Table 6-3 showing installation setting angles for high-intensity obstacle lights would be required. To accomplish these additional tasks, an *ad hoc* group was established for the duration of the meeting. The results of its work was reviewed at the end of the meeting and incorporated into the amendment proposal.

3.6 CONCLUSIONS

3.6.1 The meeting agreed that it had accomplished the assigned tasks under work programme Item 4 — Obstacle lighting.

3.6.2 In light of the foregoing, the meeting formulated the following recommendation:

RSPP

Recommendation 3/1 — Amendment to Annex 14, Volume I — Obstacle lighting

That Annex 14, Volume I be amended as indicated in the appendix to the report on this agenda item.

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APPENDIX

PROPOSED AMENDMENT TO

INTERNATIONAL STANDARDS AND RECOMMENDED PRACTICES

AERODROMES

ANNEX 14 TO THE CONVENTION ON INTERNATIONAL CIVIL AVIATION

VOLUME I (AERODROME DESIGN AND OPERATIONS)

NOTES ON THE PRESENTATION OF THE PROPOSED AMENDMENT TO ANNEX 14, VOLUME I

The text of the amendment is arranged to show deleted text with a line through it and new text highlighted with grey shading, as shown below:

1. ~~Text to be deleted is shown with a line through it.~~	text to be deleted
2. New text to be inserted is highlighted with grey shading.	new text to be inserted
3. ~~Text to be deleted is shown with a line through it~~ followed by the replacement text which is highlighted with grey shading.	new text to replace existing text

CHAPTER 6. VISUAL AIDS FOR DENOTING OBSTACLES

6.1 Objects to be marked and/or lighted

Note.— The marking and/or lighting of obstacles is intended to reduce hazards to aircraft by indicating the presence of the obstacles. It does not necessarily reduce operating limitations which may be imposed by an obstacle.

6.1.1 **Recommendation.—** *A fixed obstacle that extends above a take-off climb surface within 3 000 m of the inner edge of the take-off climb surface should be marked and, if the runway is used at night, lighted, except that:*

a) such marking and lighting may be omitted when the obstacle is shielded by another fixed obstacle;

b) the marking may be omitted when the obstacle is lighted by medium-intensity obstacle lights, Type A, by day and its height above the level of the surrounding ground does not exceed 150 m;

~~b~~c) the marking may be omitted when the obstacle is lighted by high-intensity obstacle lights by day; and

~~c~~d) the lighting may be omitted where the obstacle is a lighthouse and an aeronautical study indicates the lighthouse light to be sufficient.

6.1.2 **Recommendation.—** *A fixed object, other than an obstacle, adjacent to a take-off climb surface should be marked and, if the runway is used at night, lighted if such marking and lighting is considered necessary to ensure its avoidance, except that the marking may be omitted when~~the object is lighted by high intensity obstacle lights by day.~~:*

a) the object is lighted by medium-intensity obstacle lights, Type A, by day and its height above the level of the surrounding ground does not exceed 150 m; or

b) the object is lighted by high-intensity obstacle lights by day.

6.1.3 A fixed obstacle that extends above an approach or transitional surface within 3 000 m of the inner edge of the approach surface shall be marked and, if the runway is used at night, lighted, except that:

a) such marking and lighting may be omitted when the obstacle is shielded by another fixed obstacle;

b) the marking may be omitted when the obstacle is lighted by medium-intensity obstacle lights, Type A, by day and its height above the level of the surrounding ground does not exceed 150 m;

bc) the marking may be omitted when the obstacle is lighted by high-intensity obstacle lights by day; and

cd) the lighting may be omitted where the obstacle is a lighthouse and an aeronautical study indicates the lighthouse light to be sufficient.

6.1.4 **Recommendation.—** *A fixed obstacle above a horizontal surface should be marked and, if the aerodrome is used at night, lighted except that:*

a) such marking and lighting may be omitted when:

1) the obstacle is shielded by another fixed obstacle; or

2) for a circuit extensively obstructed by immovable objects or terrain, procedures have been established to ensure safe vertical clearance below prescribed flight paths; or

3) an aeronautical study shows the obstacle not to be of operational significance;

b) the marking may be omitted when the obstacle is lighted by medium-intensity obstacle lights, Type A, by day and its height above the level of the surrounding ground does not exceed 150 m;

bc) the marking may be omitted when the obstacle is lighted by high-intensity obstacle lights by day; and

cd) the lighting may be omitted where the obstacle is a lighthouse and an aeronautical study indicates the lighthouse light to be sufficient.

6.1.5 A fixed object that extends above an obstacle protection surface shall be marked and, if the runway is used at night, lighted.

Note.— See 5.3.5 for information on the obstacle protection surface.

6.1.6 Vehicles and other mobile objects, excluding aircraft, on the movement area of an aerodrome are obstacles and shall be marked and, if the vehicles and aerodrome are used at night or in conditions of low visibility, lighted, except that aircraft servicing equipment and vehicles used only on aprons may be exempt.

6.1.7 Elevated aeronautical ground lights within the movement area shall be marked so as to be conspicuous by day. Obstacle lights shall not be installed on elevated ground lights or signs in the movement area.

6.1.8 All obstacles within the distance specified in Table 3-1, column 11 or 12 from the centre line of a taxiway, an apron taxiway or aircraft stand taxilane shall be marked and, if the taxiway, apron taxiway or aircraft stand taxilane is used at night, lighted.

6.1.9 **Recommendation.—** *Obstacles in accordance with 4.3.2 should be marked and~~, if the aerodrome is used at night,~~ lighted, except that the marking may be omitted when the obstacle is lighted by high-intensity obstacle lights by day.*

6.1.10 **Recommendation.—** *Overhead wires, cables, etc., crossing a river, valley or highway should be marked and their supporting towers marked and lighted if an aeronautical study indicates that the wires or cables could constitute a hazard to aircraft, except that the marking of the supporting towers may be omitted when they are lighted by high-intensity obstacle lights by day.*

6.1.11 **Recommendation.—** *When it has been determined that an overhead wire, cable, etc., needs to be marked but it is not practicable to install markers on the wire, cable, etc., then high-intensity obstacle lights, Type B, should be provided on their supporting towers.*

6.2 Marking of objects

General

6.2.1 All fixed objects to be marked shall, whenever practicable, be coloured, but if this is not practicable, markers or flags shall be displayed on or above them, except that objects that are sufficiently conspicuous by their shape, size or colour need not be otherwise marked.

6.2.2 All mobile objects to be marked shall be coloured or display flags.

. . . . .

6.3 Lighting of objects

Use of obstacle lights

6.3.1 The presence of objects which must be lighted, as specified in 6.1, shall be indicated by low-, medium- or high-intensity obstacle lights, or a combination of such lights.

Note.— High-intensity obstacle lights are intended for day use as well as night use. Care is needed to ensure that these lights do not create disconcerting dazzle. Guidance on the design, location and operation of high-intensity obstacle lights is given in the Aerodrome Design Manual, *Part 4.*

6.3.2 **Recommendation.—** *Where the use of low-intensity obstacle lights, Type A, would be inadequate or an early special warning is required, then medium- or high-intensity obstacle lights should be used.*

6.3.3 **Recommendation.—** *Medium-intensity obstacle lights, Type A, B or C, should be used ~~either alone or in combination with low intensity obstacle lights~~, where the object is an extensive one or* *its height above the level of the surrounding ground is greater than 45 m. Medium-intensity obstacle lights, Types A and C, should be used alone, whereas medium-intensity obstacle lights, Type B, should be used either alone or in combination with low-intensity obstacle lights, Type B.*

Note.— A group of trees or buildings is regarded as an extensive object.

6.3.4 **Recommendation.—** *High-intensity obstacle lights, Type A, should be used to indicate the presence of an object if its height above the level of the surrounding ground exceeds 150 m and an aeronautical study indicates such lights to be essential for the recognition of the object by day.*

6.3.5 **Recommendation.—** *High-intensity obstacle lights, Type B, should be used to indicate the presence of a tower supporting overhead wires, cables, etc. where:*

—a) *an aeronautical study indicates such lights to be essential for the recognition of the presence of wires, cables, etc.; or*

—b) *it has not been found practicable to install markers on the wires, cables, etc.*

6.3.5A **Recommendation.—** *Where, in the opinion of the appropriate authority, the use of high-intensity obstacle lights, Type A or B, or medium-intensity obstacle lights, Type A, at night may dazzle pilots in the vicinity of an aerodrome (within approximately 10 000 m radius) or cause significant environmental concerns, a dual obstacle lighting system should be provided. This system should be composed of high-intensity obstacle lights, Type A or B, or medium-intensity obstacle lights, Type A, as appropriate, for daytime and twilight use and medium-intensity obstacle lights, Type B or C, for night-time use.*

Location of obstacle lights

Note.—Recommendations on how a combination of low-, medium-, and/or high-intensity lights on obstacles should be displayed are given in Appendix 6.

6.3.6 One or more low-, medium- or high-intensity obstacle lights shall be located as close as practicable to the top of the object. The top lights shall be so arranged as to at least indicate the points or edges of the object highest in relation to the obstacle limitation surface.

6.3.7 **Recommendation.—** *In the case of chimney or other structure of like function, the top lights should be placed sufficiently below the top so as to minimize contamination by smoke etc. (see Figures 6-2 and 6-3).*

6.3.8 In the case of a ~~guyed~~ tower or antenna ~~where it is not possible to locate a high intensity obstacle light on the top,~~ indicated by high-intensity obstacle lights by day with an appurtenance greater than 12 m, where it is not practicable to locate a high-intensity obstacle light on the top of the appurtenance, such a light shall be located at the highest practicable point and, if practicable, a medium-intensity obstacle light, ~~showing white,~~ Type A, mounted on the top.

6.3.9 In the case of an extensive object or of a group of closely spaced objects, top lights shall be displayed at least on the points or edges of the objects highest in relation to the obstacle limitation surface, so as to indicate the general definition and the extent of the objects. If two or more edges are of the same height, the edge nearest the landing area shall be marked. Where low-intensity lights are used, they shall be spaced at longitudinal intervals not exceeding 45 m. Where medium-intensity lights are used, they shall be spaced at longitudinal intervals not exceeding 900 m.

6.3.10 **Recommendation.—** *When the obstacle limitation surface concerned is sloping and the highest point above the obstacle limitation surface is not the highest point of the object, additional obstacle lights should be placed on the highest point of the object.*

6.3.11 Where an object is indicated by ~~low or~~ medium-intensity obstacle lights, Type A, and the top of the object is more than ~~45~~ 105 m above the level of the surrounding ground or the elevation of tops of nearby buildings (when the object to be marked is surrounded by buildings), additional lights shall be provided at intermediate levels. These additional intermediate lights shall be spaced as equally as practicable, between the top lights and ground level or the level of tops of nearby buildings, as appropriate, with the spacing not exceeding ~~45~~ 105 m (see 6.3.3).

6.3.11A Where an object is indicated by medium-intensity obstacle lights, Type B, and the top of the object is more than 45 m above the level of the surrounding ground or the elevation of tops of nearby buildings (when the object to be marked is surrounded by buildings), additional lights shall be provided at intermediate levels. These additional intermediate lights shall be alternately low-intensity obstacle lights, Type B and medium-intensity obstacle lights, Type B and shall be spaced as equally as practicable between the top lights and ground level or the level of tops of nearby buildings, as appropriate, with the spacing not exceeding 52 m.

6.3.11B Where an object is indicated by medium-intensity obstacle lights, Type C, and the top of the object is more than 45 m above the level of the surrounding ground or the elevation of tops of nearby buildings (when the object to be marked is surrounded by buildings), additional lights shall be provided at intermediate levels. These additional lights shall be spaced as equally as practicable, between the top lights and ground level or the level of tops of nearby guildings, as appropriate, with the spacing not exceeding 52 m.

6.3.12 Where high-intensity obstacle lights, Type A, are used, they shall be spaced at uniform intervals not exceeding 105 m between the ground level and the top light(s) specified in 6.3.6 except that where an object to be marked is surrounded by buildings, the elevation of the tops of the buildings may be used as the equivalent of the ground level when determining the number of light levels.

6.3.13 Where high-intensity obstacle lights, Type B, are used, they shall be located at three levels:

— at the top of the tower;
— at the lowest level of the catenary of the wires or cables; and
— at approximately midway between these two levels.

Note.— In some cases, this may require locating the lights off the tower.

6.3.13A **Recommendation.—** *The installation setting angles for high-intensity obstacle lights, Types A and B, should be in accordance with Table 6-3.*

6.3.14 The number and arrangement of low-, medium- or high-intensity obstacle lights at each level to be marked shall be such that the object is indicated from every angle in azimuth. Where a light is shielded in any direction by another part of the object, or by an adjacent object, additional lights shall be provided on that object in such a way as to retain the general definition of the object to be lighted~~, the shielded light being omitted if it does not contribute to the definition of the object to be lighted~~. If the shielded light does not contribute to the definition of the object to be lighted, it may be omitted.

Low-intensity obstacle light — Characteristics

6.3.15 Low-intensity obstacle lights on fixed objects, Types A and B, shall be fixed-red lights. ~~having an intensity sufficient to ensure conspicuity considering the intensity of the adjacent lights and the general level of illumination against which they would normally be viewed. In no case shall the intensity be less than 10 cd of red light.~~

~~*Note.— Guidance on lighting overhead high tension wires is given in the* Aerodrome Design Manual, *Part 4.*~~

6.3.15A Low-intensity obstacle lights, Types A and B, shall be in accordance with the specifications in Table 6-2.

6.3.16 Low-intensity obstacle lights displayed on vehicles, Types C and D, associated with emergency or security shall be flashing-blue and those displayed on other vehicles shall be flashing-yellow. ~~The flash frequency shall be between 60 and 90 per minute. The effective intensity of the flash shall be not less than:~~

~~a) 200 cd of yellow light when displayed on follow me vehicles; and~~

~~b) 40 cd of blue or yellow light when displayed on other vehicles.~~

6.3.16A Low-intensity obstacle lights, Types C and D, shall be in accordance with the specifications in Table 6-2.

6.3.17 Low-intensity obstacle lights on objects with limited mobility such as aerobridges shall be ~~steady~~ fixed-red. The intensity of the lights shall be sufficient to ensure conspicuity considering the intensity of the adjacent lights and the general levels of illumination against which they would normally be viewed. ~~In no case shall the intensity be less than 10 cd of red light.~~

Note.— See Annex 2 for lights to be displayed by aircraft.

6.3.17A Low-intensity obstacle lights on objects with limited mobility shall be in accordance with the specifications for low-intensity obstacle lights, Type A, in Table 6-2.

Medium-intensity obstacle light — Characteristics

6.3.18 Medium-intensity obstacle lights, Type A, shall be ~~flashing red lights, except that when used in conjunction with high intensity obstacle lights they shall be flashing white lights. The flash frequency shall be between 20 and 60 per minute. The effective intensity of the flash shall be not less than 1 600 cd of red light.~~ flashing-white lights, Type B shall be flashing-red lights and Type C shall be fixed-red lights.

6.3.18A Medium-intensity obstacle lights, Types A, B and C, shall be in accordance with the specifications in Table 6-2.

~~6.3.19 **Recommendation.**— *Medium intensity obstacle lights located on an object should flash simultaneously.*~~

6.3.19 Medium-intensity obstacle lights, Types A and B, located on an object shall flash simultaneously.

High-intensity obstacle light — Characteristics

6.3.20 High-intensity obstacle lights, Types A and B, shall be flashing-white lights.

~~6.3.21 **Recommendation.**— *The effective intensity of a high intensity obstacle light, Type A, should be variable and dependent on the background luminance as follows:*~~

~~Background luminance~~	~~Effective intensity~~
~~*above 500 cd/m²*~~	~~*200 000 ± 25% cd*~~
~~*50 to 500 cd/m²*~~	~~*20 000 ± 25% cd*~~
~~*less than 50 cd/m²*~~	~~*2 000 ± 25% cd*~~

~~6.3.22 **Recommendation.**— *The effective intensity of a high intensity obstacle light, Type B, should be variable and dependent on the background luminance as follows:*~~

~~Background luminance~~	~~Effective intensity~~
~~*above 500 cd/m²*~~	~~*100 000 ± 25% cd*~~
~~*50 to 500 cd/m²*~~	~~*20 000 ± 25% cd*~~
~~*less than 50 cd/m²*~~	~~*2 000 ± 25% cd*~~

6.3.21 High-intensity obstacle lights, Types A and B, shall be in accordance with the specifications in Table 6-2.

~~6.3.23 **Recommendation.**— *High intensity obstacle lights, Type A, located on an object should flash simultaneously at a rate between 40 and 60 per minute.*~~

6.3.22 High-intensity obstacle lights, Type A, located on an object shall flash simultaneously.

~~6.3.24 **Recommendation.** *High intensity obstacle lights, Type B, located on a tower should flash sequentially; first the middle light, second the top light and last, the bottom light. The intervals between flashes of the lights should approximate the following ratios:*~~

~~*Flash interval between*~~	~~*Ratio of cycle time*~~
~~*middle and top light*~~	~~*1/13*~~
~~*top and bottom light*~~	~~*2/13*~~
~~*bottom and middle light*~~	~~*10/13*~~

~~The cycle frequency should be 60 per minute.~~

6.3.23 High-intensity obstacle lights, Type B, indicating the presence of a tower supporting overhead wires, cables, etc. shall flash sequentially; first the middle light, second the top light and last, the bottom light. The intervals between flashes of the lights shall approximate the following ratios:

Flash interval between	*Ratio of cycle time*
middle and top light	1/13
top and bottom light	2/13
bottom and middle light	10/13

Insert new Tables 6-2 and 6-3 as follows:

Table 6-2 Characteristics of obstacle lights

1	2	3	4	5	6	7	8	9	10	11	12
Light Type	Colour	Signal type/ (flash rate)	Peak intensity (cd) at given Background Luminance			Beam Spread (c)	Intensity (cd) at given Elevation Angles when the light unit is levelled (d)				
			Above 500 cd/m²	50-500 cd/m²	Below 50 cd/m²		-10° (e)	-1° (f)	±0° (f)	+6°	+10°
Low-intensity, Type A (fixed obstacle)	Red	Fixed	N/A	10 min	10 min	10°	N/A	N/A	N/A	10 min	10 min
Low-intensity, Type B (fixed obstacle)	Red	Fixed	N/A	32 min	32 min	10°	N/A	N/A	N/A	32 min	32 min
Low-intensity, Type C (mobile obstacle)	Yellow/Blue (a)	Flashing (60-90 fpm)	N/A	40 min (b) 400 max	40 min (b) 400 max	12° (g)	N/A	N/A	N/A	N/A	N/A
Low-intensity, Type D Follow-me Vehicle	Yellow	Flashing (60-90 fpm)	N/A	200 min (b) 400 max	200 min (b) 400 max	12° (h)	N/A	N/A	N/A	N/A	N/A
Medium-intensity, Type A	White	Flashing (20-60 fpm)	20 000 (b) ± 25%	20 000 (b) ± 25%	2 000 (b) ± 25%	3° min	3% max	50% min 75% max	100% min	N/A	N/A
Medium-intensity, Type B	Red	Flashing (20-60 fpm)	N/A	N/A	2 000 (b) ± 25%	3° min	N/A	50% min 75% max	100% min	N/A	N/A
Medium-intensity, Type C	Red	Fixed	N/A	N/A	2 000 (b) ± 25%	3° min	N/A	50% min 75% max	100% min	N/A	N/A
High-intensity, Type A	White	Flashing (40-60 fpm)	200 000 (b) ± 25%	20 000 (b) ± 25%	2 000 (b) ± 25%	3°-7°	3% max	50% min 75% max	100% min	N/A	N/A
High-intensity, Type B	White	Flashing (40-60 fpm)	100 000 (b) ± 25%	20 000 (b) ± 25%	2 000 (b) ± 25%	3°-7°	3% max	50% min 75% max	100% min	N/A	N/A

Note.— This Table does not include recommended horizontal beam spreads. 6.3.14 requires 360° coverage around an obstacle. Therefore, the number of lights needed to meet this requirement will depend on the horizontal beam spreads of each light as well as the shape of the obstacle. Thus, with narrower beam spreads, more lights will be required.

a) See 6.3.16
b) Effective intensity, as determined in accordance with the *Aerodrome Design Manual*, Part 4.
c) Beam spread is defined as the angle between two directions in a plane for which the intensity is equal to 50% of the lower tolerance value of the intensity shown in columns 4, 5 and 6. The beam pattern is not necessarily symmetrical about the elevation angle at which the peak intensity occurs.
d) Elevation (vertical) angles are referenced to the horizontal.
e) Intensity at any specified horizontal radial as a percentage of the actual peak intensity at the same radial when operated at each of the intensities shown in columns 4, 5 and 6.
f) Intensity at any specified horizontal radial as a percentage of the lower tolerance value of the intensity shown in columns 4, 5 and 6.
g) Peak intensity should be located at approximately 2.5° vertical.
h) Peak intensity should be located at approximately 17° vertical.

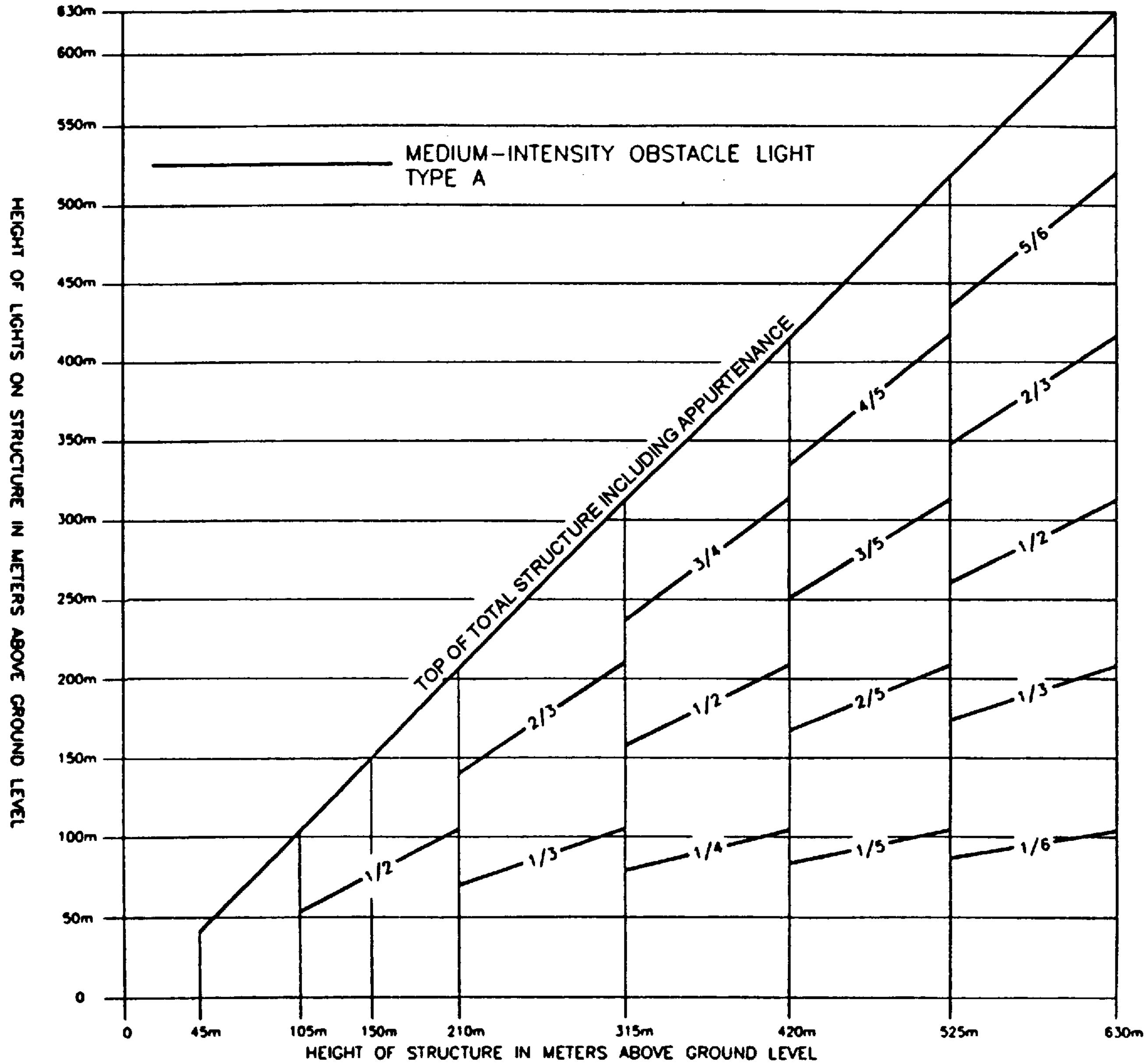
fpm - flashes per minute; N/A - not applicable

Table 6-3 Installation setting angles for high-intensity obstacle lights

Height of light unit above terrain	Angle of the peak of the beam above the horizontal
greater than 152 m AGL	0°
122 m to 151 m AGL	1°
92 m to 122 m AGL	2°
less than 92 m AGL	3°

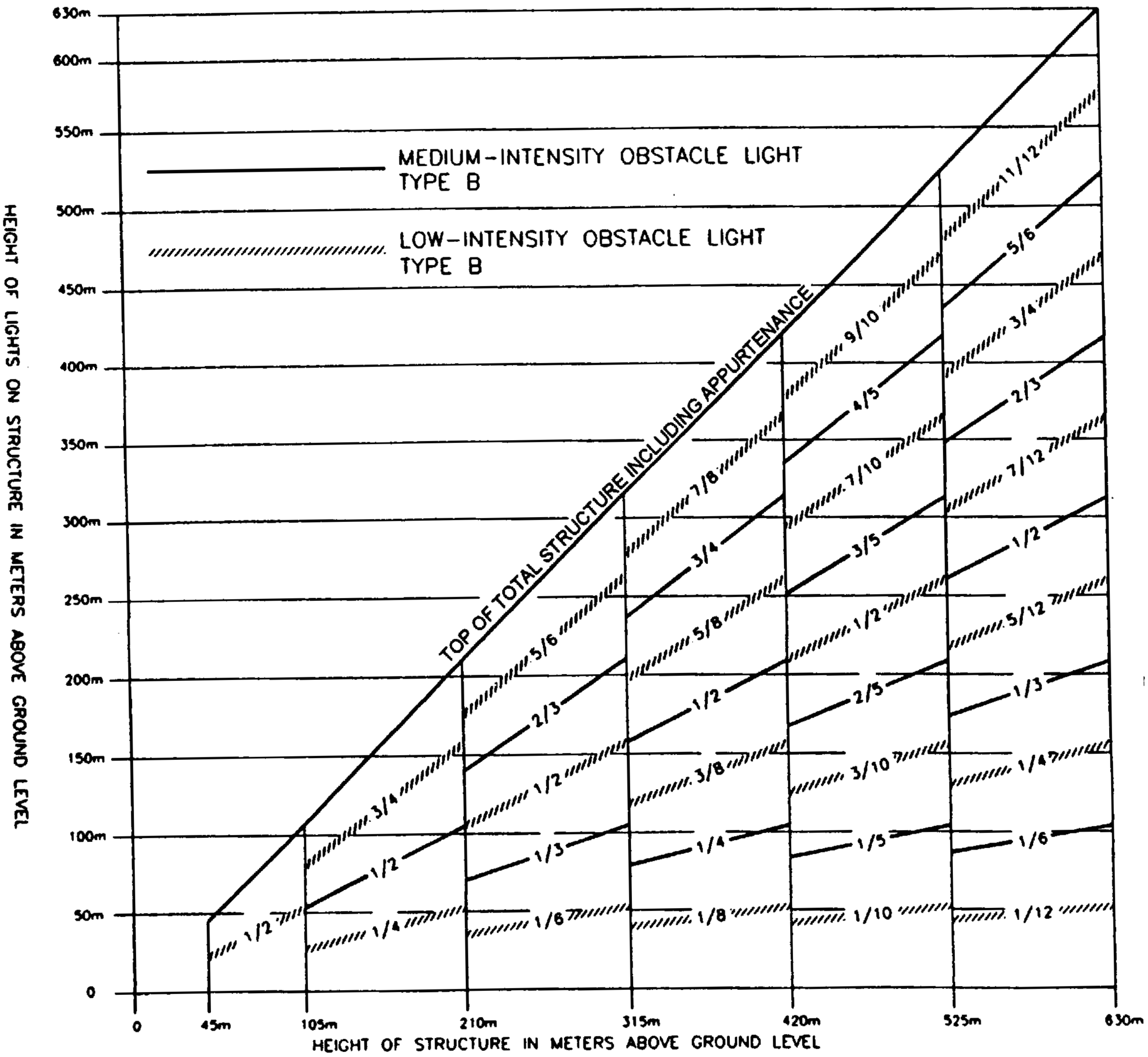
Insert new Appendix 6 as follows:

APPENDIX 6. LOCATION OF LIGHTS ON OBSTACLES



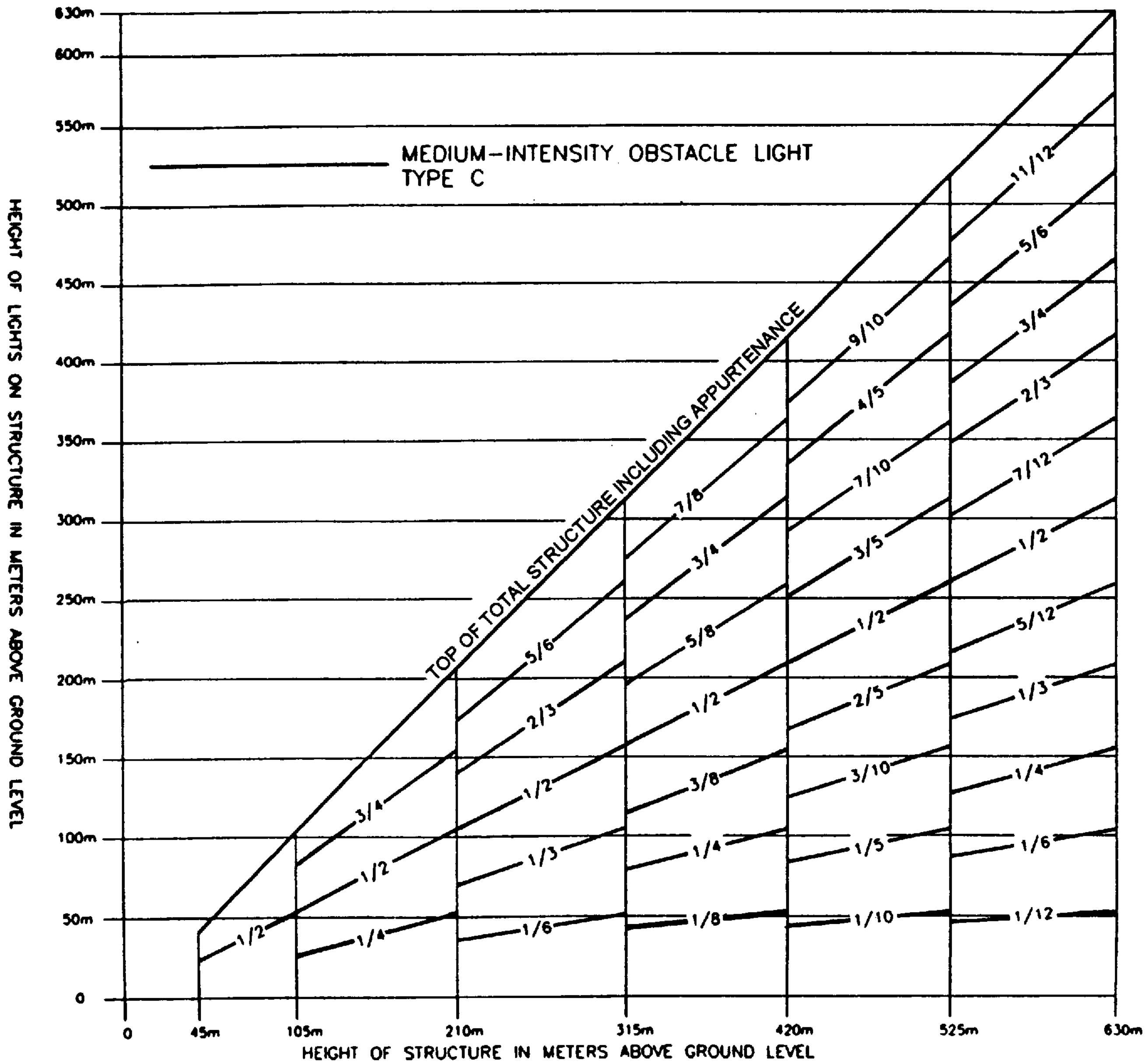
Note.- High-intensity obstacle lighting is recommended on structures more than 150 m AGL. If medium-intensity lighting is used, marking will also be required.

Figure 5.1 Medium-intensity flashing-white obstacle lighting system, Type A



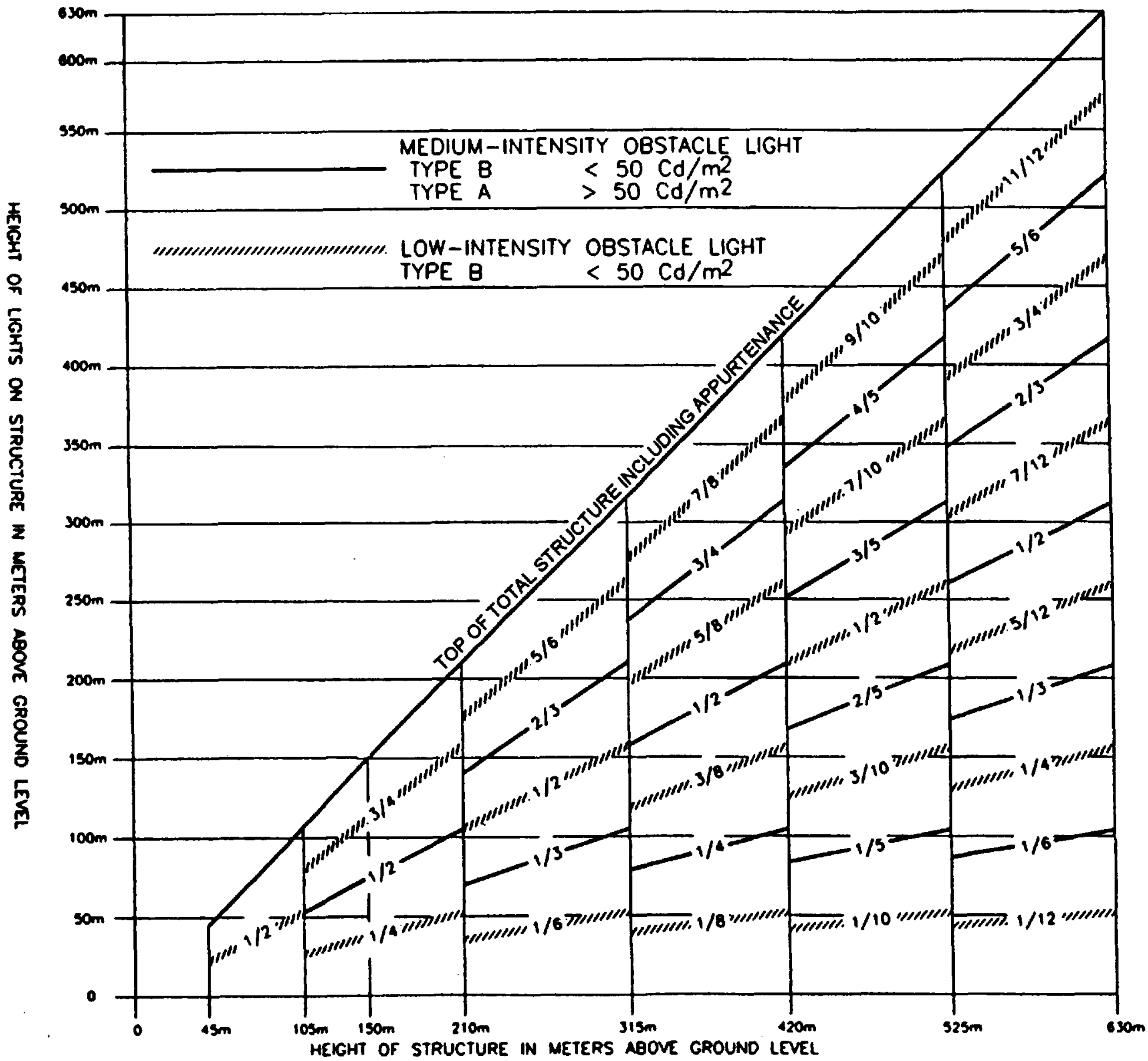
Note.- For night-time use only

Figure 5.2 Medium-intensity flashing-red obstacle lighting system, Type B



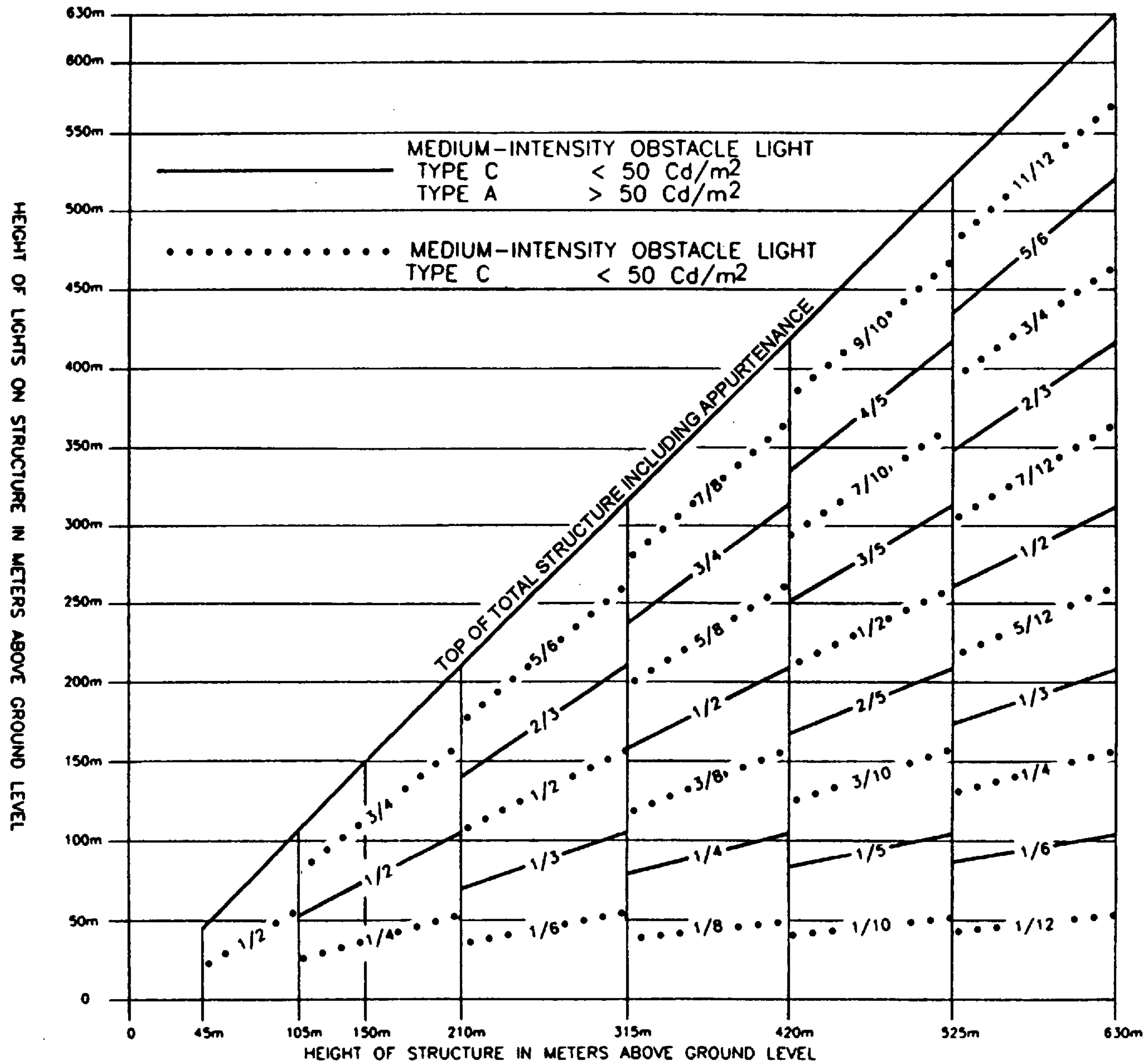
Note.- For **night-time use only**

Figure 5.3 Medium-intensity fixed-red obstacle lighting system, Type C



Note.- High-intensity obstacle lighting is recommended on structures more than 150 m AGL. If medium-intensity lighting is used, marking will also be required.

Figure 5.4 Medium-intensity dual obstacle lighting system, Type A/Type B



Note.- High-intensity obstacle lighting is recommended on structures more than 150 m AGL. If medium-intensity lighting is used, marking will also be required.

Figure 5.5 Medium-intensity dual obstacle lighting system, Type A/Type C

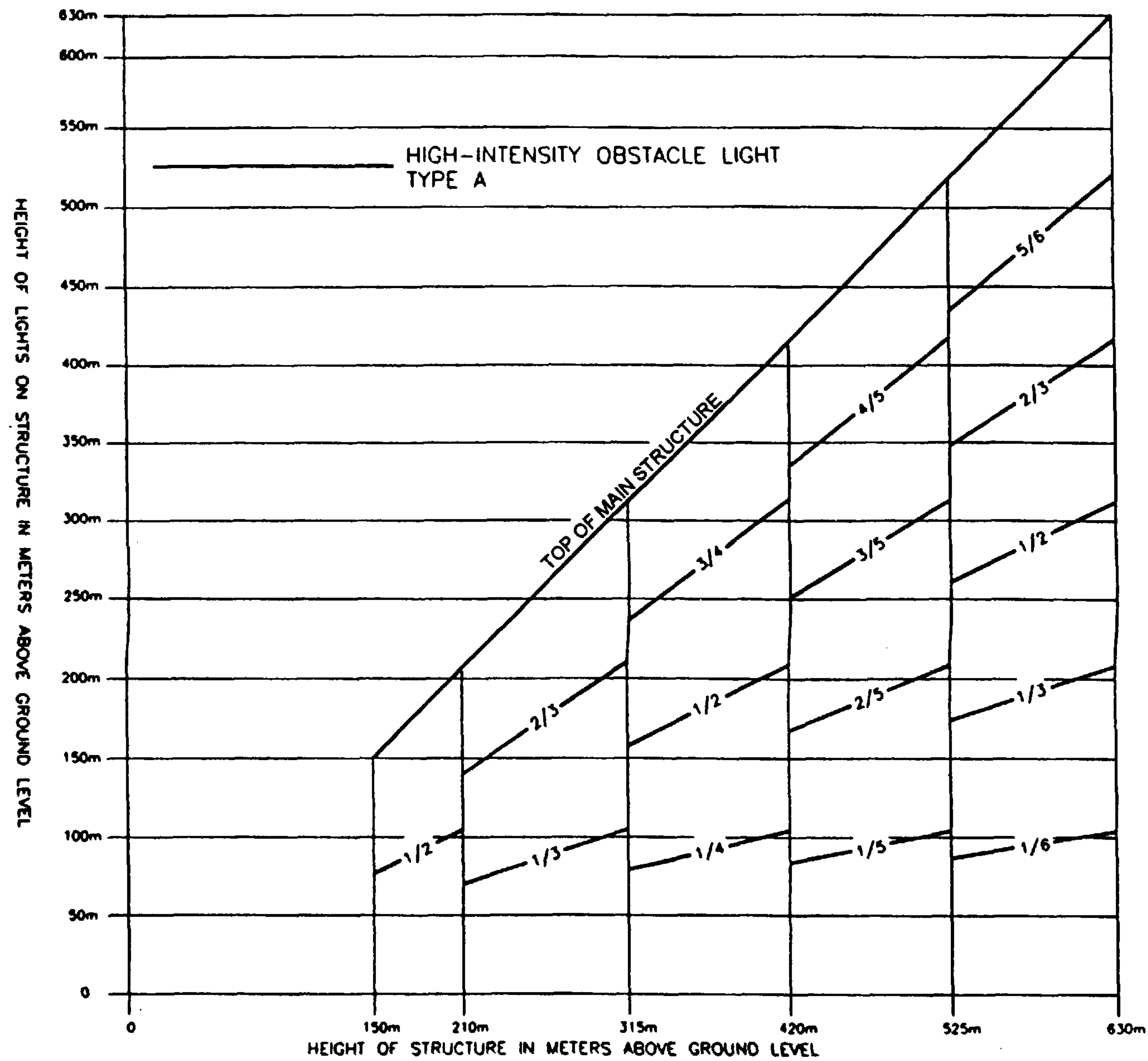


Figure 5.6 High-intensity flashing-white obstacle lighting system, Type A

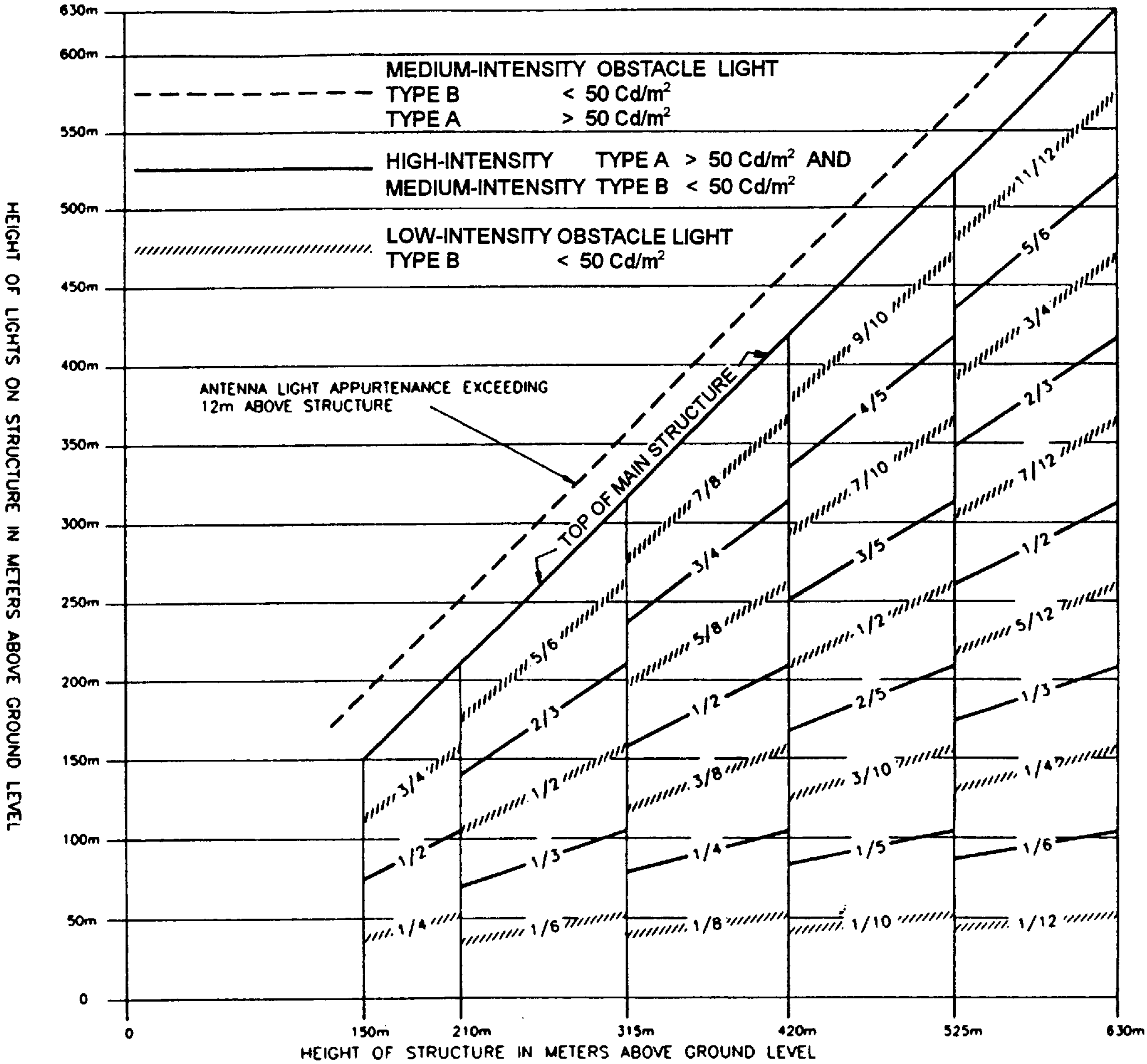


Figure 5.7 High-/medium-intensity dual obstacle lighting system, Type A/Type B

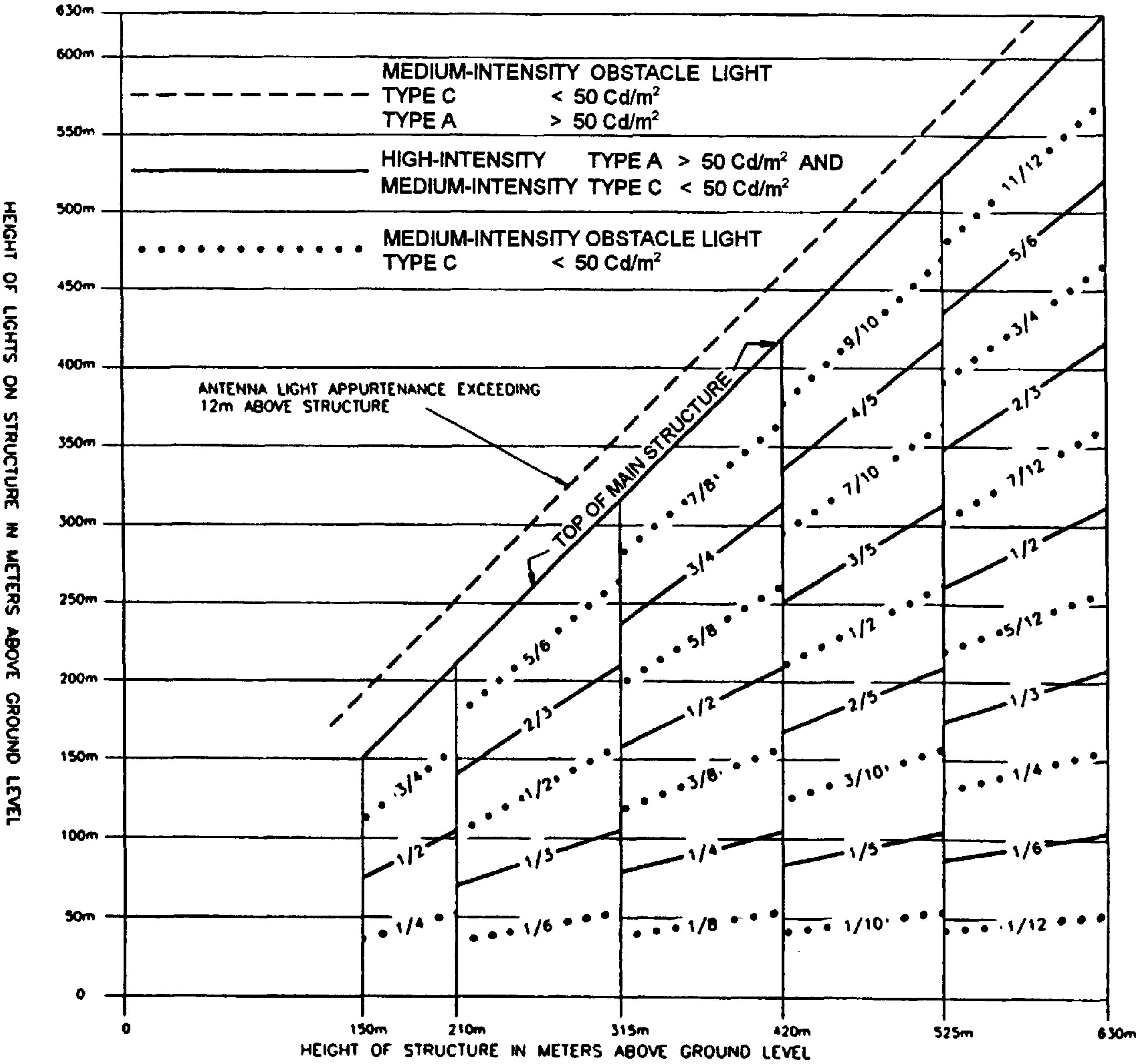


Figure 5.8 High-/medium-intensity dual obstacle lighting system, Type A/Type C

End of new Appendix 6

ATTACHMENT A. GUIDANCE MATERIAL SUPPLEMENTARY TO ANNEX 14, VOLUME I

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13. Lighting of unserviceable areas and vehicles

13.1 Unserviceable areas

Where a temporarily unserviceable area exists, it may be marked with ~~steady~~ fixed red lights. These lights should mark the most potentially dangerous extremities of the area. A minimum of four such lights should be used, except where the area is triangular in shape where a minimum of three lights may be employed. The number of lights should be increased when the area is large or of unusual configuration. At least one light should be installed for each 7.5 m of peripheral distance of the area. If the lights are directional, they should be orientated so that as far as possible their beams are aligned in the direction from which aircraft or vehicles will approach. Where aircraft or vehicles will normally approach from several directions, consideration should be given to adding extra lights or using omnidirectional lights to show the area from these directions. Unserviceable area lights should be frangible. Their height should be sufficiently low to preserve clearance for propellers and for engine pods of jet aircraft.

~~13.2 Other than follow me vehicles~~

~~The following light characteristics are considered suitable for obstacle lighting under night time conditions:~~

~~a) 360° azimuth coverage in either yellow (service vehicles) or blue (emergency and security vehicles) colour;~~

~~b) minimum effective intensity in the horizontal plane not less than 40 cd nor more than 400 cd (the upper cd limit is required to avoid dazzle);~~

~~c) the beam spread measured to 1/10 of peak intensity extending from 10° below to 15° above the horizontal; and~~

~~d) flash rate 75 ± 15 flashes per minute.~~

~~13.3 Follow me vehicles~~

~~The following light characteristics are considered suitable for obstacle lighting under night time conditions:~~

~~a) 360° azimuth coverage in yellow colour;~~

~~b) minimum effective intensity in the horizontal plane not less than 200 cd nor more than 400 cd (the upper cd limit is required to avoid dazzle);~~

~~c) vertical light distribution as shown in Figure A-8; and~~

~~d) flash rate 75 ± 15 flashes per minute.~~

Editorial Note.— Delete Figure A-8. Follow-me vehicle obstacle light.

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PART II — REPORT ON AGENDA ITEM 4

Agenda Item 4: Reduced lighting for precision approach runways

4.1 INTRODUCTION

4.1.1 The purpose of this agenda item was to:

a) study the possibility of reducing the patterns of lighting currently specified in Annex 14, Volume I for precision approach runways categories II and III;

b) study the impact of reduced lighting on the characteristics of touchdown zone marking;

c) study the possibility of specifying a single pattern of touchdown zone marking;

d) review the possibility of reducing the length of precision approach category I lighting systems; and

e) review and update the current Annex 14, Volume I specifications on maintenance of aerodrome lighting systems with the view to promoting standardized procedures for measuring the characteristics of aeronautical ground lights included in such systems.

4.2 STUDY OF SIMPLIFIED APPROACH AND RUNWAY LIGHTING PATTERNS

4.2.1 General

4.2.1.1 The approach and runway lighting systems currently specified in Annex 14, Volume I were developed over 20 years ago. Operational experience has shown that the lighting is adequate for the purpose for which it was designed.

4.2.1.2 However, the cost of installation, operation and maintenance of lighting conforming to these standards is high. As a result, it has become evident that consideration should be given to identifying means by which the lighting patterns could be reduced so that more aerodromes can provide all weather operations capability to the users.

4.2.1.3 At the VAP/12 Meeting, the United Kingdom reported the results of the research funded by the Civil Aviation Administration (CAA) being conducted by the Defense Research Agency (DRA) to address these issues. Following VAP/12, the Air Navigation Commission requested the panel to study the possibility of reducing the patterns of lights currently specified in Annex 14, Volume I. To this end, the panel established the Working Group on Reduced Lighting for Precision Approach Runways.

4.2.1.4 Six meetings of the working group have been held. Extensive flight and simulator trials were conducted by the United Kingdom and reported to the working group. The United States had also conducted a number of relevant studies and simulator trials. Additional data was also provided by the other working group members. At an early stage, the working group had agreed to retain the length of the touchdown zone lighting. The present length of 900 m was part of the concept of the obstacle free zone developed by the Obstacle Clearance panel (OCP) and had been chosen to indicate the latest point for a pilot to initiate a balked landing. Thus, a reduction in the length of the touchdown zone lighting would leave the pilot without this operationally important cue.

4.2.1.5 The lighting currently specified in Annex 14, Volume I for precision approach runways categories II and III is illustrated in Figure 4-1 below. The reduced lighting pattern developed by the working group on the basis of the United Kingdom trials is illustrated in Figure 4-2 below.

4.2.1.6 As a result of the studies carried out by the working group, the proposal for amendment to Annex 14, Volume I detailed at Appendix A to the report on this agenda item was developed for consideration by the meeting.

4.2.1.7 The amendment proposal includes the following changes:

Precision approach category I and runway lighting systems

a) **Approach lighting system**

— Omission of the distance-coding from the centre line.

b) **Runway lighting system**

— No change.

Precision approach categories II and III and runway lighting systems

a) **Approach lighting system**

— Increase in the longitudinal spacing of side row barrettes from 30 m to 60 m.

— Omission of the distance-coding from the centre line.

b) **Runway centre line lights**

— Inclusion of a uniform longitudinal spacing of 30 m in visibilities down to an runway visual range (RVR) of 300 m, below which a longitudinal spacing of 15 m should be used.

c) **Runway touchdown zone lights**

— Inclusion of a uniform longitudinal spacing of 60 m between pairs of barrettes.

— Reduction of the minimum number of lights in a barrette from 3 to 2.

4.2.2 **United Kingdom research and trials programme**

4.2.2.1 The initiative for the conduct of the study of simplified approach and runway lighting patterns for low visibility operations came from the United Kingdom, but the need for the study was well supported by panel members. However, until the latter stages of the work, nearly all the data was provided by the United Kingdom based on ongoing trials. During the fifth meeting of the working group the need for the study was enhanced by a research initiative from the United States to review the needs for approach lighting to support GPS-based approaches to category I limits.

4.2.2.2 The objective of the United Kingdom simulation and flight trials was to determine whether the proposed patterns of lights, if implemented, would support operational safety and regularity levels at least as high as those currently achieved in the United Kingdom. In particular, the trials evaluated the lighting in five aspects:

a) adequacy of the displacement cues during decision making and final manoeuvres prior to the flare or overshoot;

b) adequacy of the runway threshold definition;

c) adequacy of textural cues in the touchdown zone during the flare and the touchdown;

d) adequacy of the runway centre line guidance for the landing ground roll; and

e) adequacy of the runway centre line guidance for the take-off or aborted take-off.

4.2.2.3 The scope and results of the trials were summarized in the DRA report "Simplified approach and runway lighting patterns for low visibility operations" as follows:

a) the research programme was intended to investigate the feasibility of reducing the amount of lighting required to support precision approach and landing operations and low visibility take-offs. If adopted, the proposals would significantly reduce the acquisition and maintenance costs of aerodrome lighting systems and thereby encourage the provision of those facilities that are strictly necessary to allow modern aircraft to take full benefit of their avionics capabilities;

b) the programme was structured to reveal any inadequacies in the reduced patterns in terms of both the safety and regularity of operations. These issues were addressed in both normal and abnormal situations to demonstrate the accuracy of the cues provided by the more limited lighting;

c) a total of 54 pilots took part in the various simulation experiments and 4 pilots participated in the fog flying. In all cases the pilots were fully conversant with the operational procedures they were required to follow. Their experience of low visibility operations covered a wide range. A small percentage only had recent simulator experience, but a large proportion had current operational experience in the relevant visibilities. At least one pilot had carried out over 100 actual landings in category III conditions;

d) in the preparations for the simulation trials, care was taken to ensure that the segments of lighting seen by pilots were an authentic representation of the lighting seen in operation. This was achieved by reference to a large database obtained in earlier fog flying trials conducted over many years by the DRA (formerly BLEU/RAE). The similarity of the data obtained in the fog flying and in simulation trials demonstrated that the use of simulators was a valid means of testing the proposed lighting systems;

e) throughout the trials, there was very strong pilot support for the view that the current lighting patterns were over-designed and that in many cases a reduction in the lighting and a resulting reduction in glare would be beneficial;

f) the large amount of data obtained, validated by pilot comments, showed that the reduced patterns could support low visibility operations to current limits of visibility at the currently required levels of safety and regularity. Furthermore, the proposed patterns had sufficient redundancy within them to withstand further operational reductions that could result from equipment failures both within the lighting and on the aircraft;

g) one clear trend noted throughout the programme of trials was the significant increase in the percentage of pilots who rated the proposed lighting adequate for the task in all circumstances after they had carried out their trial sorties. This trend illustrated the need for actual experience of the patterns before drawing any conclusions as to their acceptability for future use. A considerable number of experienced and qualified pilots stated categorically that prior to conducting the trial they were strongly of the opinion that the reduced pattern would not be sufficient. Having conducted the trial and achieved all the tasks safely and at an acceptable workload, these pilots were then convinced of the efficacy of the reduced lighting. Throughout the whole project no pilot rated the patterns as other than adequate for the task;

h) the adequacy of the patterns was rigorously tested during the fog flying by arranging to deliver the aircraft to the point of decision well displaced from the normal delivery envelope. Furthermore, the aircraft often had abnormally large off-data attitudes at the decision height which itself was purposely set at high value for the RVR existing for the approach. Overall this resulted in the aircraft being operated safely and regularly well outside normal limits, thus demonstrating the redundancy of cues still available in the modified patterns;

i) the trials were conducted by pilots with various levels of fatigue. Many of the subject pilots participated on rest days from company flying. However, this was not always the case. In particular, the B767 trials included pilots who had been on flying duties between 08:30 and 17:00 hours and who then participated in the trials between 22:00 and 02:00 hours;

j) the results obtained during the B747 simulator trials indicated that there were no particular problems associated with the take-off and landing operations of wide-bodied aircraft in low visibility conditions, down to current limits;

k) the data presented, in addition to supporting the concept of reduced lighting, demonstrated many of the assumptions that underlay the basic design of the current lighting patterns. In particular, the data showed:

1) the importance of a well-defined green threshold;

2) the high workload involved with manual landings in RVRs less than 800 m in the absence of centre line and touchdown zone lighting; and

3) the necessity for runway centre line lighting to be available for the ground roll or take-off in RVRs less than 400 m.

l) In addition to the standard 900 m long touchdown zone lighting, the B747 simulator trials also included a reduced 600 m long touchdown zone lighting. Since most of the landings were autolands in very low visibility, the touchdown zone lighting was not used extensively to provide flare cues or landing distance information. For those landings flown manually in 400 m RVR conditions, the length of the touchdown zone lighting was not shown to be an issue and was not the cause of the overshoots that occurred. In the final debriefing session, a minority of pilots felt that for manual landings the 600 m zone might be too short. The trials, however, did not provide any conclusive evidence in support of this;

m) No clear consensus or strong preferences emerged from the B747 simulator trials in relation to the length of the touchdown zone light barrettes and the supplementary red approach light barrettes. Whilst preferences were divided between a length of 1.5 m and 4.5 m within the pilot sample, there were also variations in preference between the take-off and landing case with different lengths for the touchdown zone light barrettes and the supplementary red approach light barrettes being suggested by one pilot;

n) On the basis of the extensive simulation and flight trials, the DRA report concluded that:

1) the pattern, as shown in Figure 21 of the report, would support category II landings and take-offs when the visibility was greater than 400 m RVR. The proposed pattern in Figure 21 included *inter alia* no runway centre line lights, a uniform longitudinal spacing of 60 m between touchdown zone lighting barrettes and a reduced 600 m long touchdown zone lighting; and

2) the pattern, as shown in Figure 22 of the report, would support category III landings down to an RVR of 75 m and take-offs down to an RVR of 125 m. The proposed pattern in Figure 22 included *inter alia* a uniform longitudinal spacing of 30 m for runway centre line lights, a uniform longitudinal spacing

of 60 m between touchdown zone lighting barrettes and a reduced 600 m long touchdown zone lighting.

4.2.3 **Discussion**

4.2.3.1 One of the difficulties that the working group encountered was a reluctance to propose changes to lighting systems that are generally perceived as being operationally satisfactory. The working group did not find it easy to balance this reluctance and the predicted operational benefits in terms of enhanced capabilities at many aerodromes that the United Kingdom research showed could be available.

4.2.3.2 The choice of light spacing for the runway centre line clearly illustrated this dilemma. Data was provided to the working group that documented the results of simulation and flight tests which clearly showed that in all visibility conditions, a 30 m spacing can support normal operations and operations when very significant equipment failures occur. Furthermore, this performance was achieved in a manner that protected safety levels. Operational data was also provided by the United Kingdom which showed that the full range of runway operations had taken place in the past on many occasions with 30 m centre line spacing. Nevertheless, the need for a 15 m spacing in visibility conditions less than an RVR of 300 m was supported by several working group members. A trial conducted with a B747 simulator in the Kingdom of the Netherlands was the main research evidence offered to support the need for 15 m spacing. In addition, a United States simulator evaluation of the various Joint Aviation Authority (JAA) requirements for operations indicated that pilots preferred the 15 m runway centre line light spacing over the 30 m spacing in RVR conditions of 150 m.

4.2.3.3 In order to illustrate the scale of applicability of the proposed amendment related to precision approach category II and III lighting systems, the working group developed the following table summarizing the number of category II and III runways in their States.

State	CAT II approach ends	CAT III approach ends	Remarks
Australia	4	-	Equipped for CAT II/III
Belgium	1	2	
Canada	6	3	Approach lighting systems ALSF-2, 900 m long. CAT I minima based on decision height only. Inset pavement lights in accordance with Annex 14, Volume I.
France	-	19	Calvert approach lighting systems. Runway centre line light spacing 15 m. Longitudinal spacing between touchdown zone barrettes 30 m (60 m on one runway).
Japan	2	3	Runway centre line light spacing 15 m.

State	CAT II approach ends	CAT III approach ends	Remarks
The Netherlands	2	3	Plans exist to upgrade two CAT I runways to CAT II/III. Runway centre line light spacing 15 m.
United Kingdom	1	22	Runway centre line light spacing 15 m.
United States	73-75	36-37	Will allow take-off down to 180 m RVR. Runway centre line light spacing 15 m. 550 m RVR is the lowest CAT I with only HIRL. Below 550 m RVR, centre line lights and touchdown zone barrettes required. The US uses ALSF-2 which does not use coded approach centre line.
Spain	3	-	Runway centre line light spacing 15 m. Longitudinal spacing between touchdown zone barrettes 30 m.
Sweden	4	-	Runway centre line light spacing 30 m.

Note.— Data supplied in September 1996.

4.2.3.4 The working group had considered that it could be possible that the proposed amendments would be found to be the first stage of a more comprehensive amendment to Annex 14, Volume I lighting specifications meeting future needs for all weather operations. Recent advances in GNSS capabilities had heightened the prospect of providing category I, II and III approach and landing capabilities at numerous airports. In addition to the considerable expense of installing standard approach lighting systems to support these approaches, many airports did not have the land area that would be required for the installation of such systems. Therefore, additional work would be required to determine if modified approach lighting configurations could be developed that would be less expensive and occupy less land area without compromising safety.

4.2.3.5 The results of the research and trials programme conducted in the United Kingdom was reviewed by the meeting. The meeting also viewed a video on the trials programme complementing the technical report on the work carried out. One member expressed considerable concern about the redundancy of the proposed reduced lighting system in case of failure of one circuit. He further advised that results of in-field testing conducted in his State indicated that any reduction of the currently specified lighting system would not be acceptable to pilots. He would, therefore, not support the proposed reduction in lighting patterns.

4.2.3.6 The meeting was advised that the research and trials programme had shown that there was considerable spare capacity in the currently specified system and that even the proposed reduced system was nowhere near the critical level. In effect, the simulation had proved that the breakdown of one circuit would not leave the pilot with inadequate visual cues. In addition, it was considered that a failure of a whole circuit was extremely rare. The reliability of visual aids had increased considerably in recent years.

4.2.3.7 The rationale behind the current supplementary patterns specified some 30 years ago was as follows:

a) the need for a means of making a visual check of the accuracy of lateral delivery for coupled approaches on the instrument landing system (ILS) for decision heights less than 200 ft due to poor delivery of early ILS systems;

b) the need for textural cues during the flare manoeuvre at night or in reduced visibilities; and

c) the need for steering cues during the roll-out and for take-off.

4.2.3.8 Research and in-service operational data had shown that, for aircraft and runways equipped with modern visual and/or electronic equipment, these requirements could be relaxed. Specifically, because modern systems delivered the aircraft more accurately, there was no requirement to indicate offset distance which was the original purpose of the red approach barrettes (although they also gave an indication of the imminent approach to the threshold).

4.2.3.9 The meeting was further advised that the pilots participating in the trials programme had indicated no concern about the reduced patterns of the approach lighting system. All discussions had centred around the runway centre line lighting and the related light spacing.

4.2.3.10 An issue that generated considerable discussion in the meeting was the proposed reduction of the minimum number of lights in a touchdown zone light barrette from 3 to 2. It was considered that two lights did not actually constitute a barrette and, therefore, the meeting decided that the current specification should be retained.

4.2.3.11 In light of the above, the meeting, except for the reduction of the minimum number of lights in a barrette, endorsed the proposal developed by the working group for amendment to Annex 14, Volume I. The meeting also saw the need to study further the use of partially serviceable approach and runway lighting systems and as to when they should be declared to have failed. It was considered that serviceability levels would have to be considered in the future when studying the possibility of further modifying approach and runway lighting systems.

4.3 ISSUES IN RELATION TO TOUCHDOWN ZONE MARKING

4.3.1 General

4.3.1.1 The task originally assigned to the panel in relation to touchdown zone marking required the resolution of two problems, namely the elimination of the overlap between the fixed distance and touchdown zone markings and the simplification of the distance-coded pattern of the touchdown zone marking. It was felt that the use of the distance-coded pattern involved more paint and, in certain situations, rendered the runway slippery. VAP/12 was only able to recommend means of removing the overlap between the fixed distance and touchdown zone marking and developed a proposal for amendment to Annex 14, Volume I specifications on touchdown zone marking to this end. This amendment was incorporated in the Second Edition of Annex 14, Volume I.

4.3.1.2 Subsequent to VAP/12 and as desired by the Air Navigation Commission (ANC), States were invited to indicate:

a) which pattern of touchdown zone marking (*viz.* basic or distance-coded) they used;

b) the problems encountered with the pattern they used; and

c) whether they would favour simplification of the pattern.

4.3.1.3 The responses indicated that the distance-coded pattern was used in a majority of States (26:13). Only a minority of responding States reported any operational problems with the pattern they used. As regards support for simplification of the pattern, the responses indicated an almost even division of opinion (16:18). Since the replies were almost evenly divided, the ANC agreed to retain both the patterns. At the same time, the ANC considered it necessary to study:

a) the impact of reduced lighting on the characteristics of the touchdown zone marking; and

b) the possibility of specifying a single pattern of touchdown zone marking.

4.3.1.4 The panel had assigned the two issues to the Working Group on Reduced Lighting for Precision Approach Runways.

4.3.2 **Discussion**

4.3.2.1 At its third meeting, the working group examined the two issues.

4.3.2.2 The proposed reduced lighting for precision approach runways did not include a reduction in length of the touchdown zone lighting. Therefore, the working group considered that the proposed reduction in lighting would have no effect on the length or patterns of the touchdown zone marking.

4.3.2.3 With regard to specifying a single pattern of touchdown zone marking, it was recalled that the responses to the question regarding simplification of the pattern were evenly divided. In this context, the proponents had pointed out that:

a) operational value of the distance-coded pattern was questionable;

b) increased presence of colour-coded runway and centre line lighting reduced the value of the distance-coded marking;

c) an improvement in runway friction characteristics could be achieved; and

d) the cost of installing and maintaining the marking could be reduced.

4.3.2.4 On the other hand, those opposed to the simplification of the marking had advanced the following arguments:

a) the distance information provided by the distance-coded pattern had been found to be valuable. In fact, operators often asked for more distance information;

b) the distance-coded pattern was widely used without any adverse comments;

c) any degradation in the friction could be prevented by the use of paints with improved friction characteristics; and

d) the cost of the marking was off-set by the guidance provided in aeronautical operations.

4.3.2.5 The working group had evaluated the above responses and had concluded that the arguments for and against simplification were well balanced. It further considered that both patterns had proven operationally effective and, therefore, saw no need to standardize on the basis of a single pattern.

4.3.2.6 The meeting fully endorsed the conclusions of the working group.

4.4 REDUCED LENGTH OF PRECISION APPROACH CATEGORY I LIGHTING SYSTEMS

4.4.1 Operational scenario

4.4.1.1 The approach lighting standard depends on an operational requirement to provide a pilot with sufficient visual references to enable the decision as to whether to continue the approach below the decision height to be made.

4.4.1.2 At the decision height, the pilot must declare the decision and, if the decision is to overshoot, immediately initiate that action. There is, therefore, a decision making process that must be completed when the aircraft reaches the decision height. The time required for the decision process in category I conditions is commonly agreed to be 3 seconds on the advice of members of the All Weather Operations Panel (AWOP).

4.4.1.3 A recent study by the Federal Aviation Administration (FAA) for an AWOP sub-group studying advanced surface movement guidance and control systems (A-SMGCS) found evidence for pilot reaction times in the range of 0.3 - 15 seconds depending on the task. In another study, a time of 4 seconds was identified as the time required by a pilot to make a decision to manoeuvre an aircraft to avoid a collision having already identified that a potential collision situation exists. Consequently, it should be emphasized that decision making takes time and 3 seconds for the land/overshoot decision is not an excessive estimate.

4.4.2 **Discussion**

4.4.2.1 The meeting was advised that a theoretical evaluation of the standard precision approach category I lighting system performed in the United Kingdom had indicated that the currently specified length was correct. If shorter lengths were used, then either the decision height must be reduced or the RVR limit must be raised. It was pointed out that, if the decision making process started at 200 feet, the operational basis of the procedure would be affected. In effect, decisions would then be made below 200 feet. Such procedures would have safety implications. On the other hand, if the RVR, in which the decision was being made, was in actual operation nearly always above the limiting value, then the pilot would obtain adequate cues and continue to a successful landing.

4.4.2.2 It was recognized that the original category I limits (200 feet decision height, 800 m RVR) were very conservative. As a result, the ICAO specification had changed the RVR limit to 550 m for precision approach runways category I. This effectively had used the "spare" capacity in the system. Validation that both the limiting RVR and the length of lighting could be simultaneously reduced had not been achieved.

4.4.2.3 The meeting was further apprised of the evaluation of the 720 m long precision approach category I lighting system currently used in Canada and the United States included in the study on simplified approach and runway lighting patterns for low-visibility operations conducted in the United Kingdom. None of the pilots involved in the related trials considered this lighting pattern adequate. However, it was acknowledged that the number of approaches included in the evaluation was very limited.

4.4.2.4 In view of the fact that the 720 m long precision approach category I lighting system had been in use for a long time in both Canada and the United States without any known operational problems, the working group had been encouraged to provide additional data on the performance of the system and/or undertake further evaluations of the system. No further data, however, supporting the 720 m long approach lighting system had been presented for review by the working group. One of the reasons being that data on actual in-service experiences related to missed approaches during the use of the North American precision approach category I lighting system were not recorded and, therefore, not readily available. In view of this, the working group had concluded that additional data supporting the use of such systems might have to be based on simulation.

4.4.2.5 Nonetheless, a proposal for a reduction of the overall length of the standard precision approach category I lighting system from 900 m to 720 m had been submitted for review by the meeting. In this context, the meeting noted that

a) the existing length of the approach lighting was established on the basis of specific operational parameters including landing success rates, a specific minimum visual segment being available before the decision height and an allowance for the decision making process prior to the decision (Annex 14, Volume I, paragraph 5.3.4.10, *Note* and Attachment A paragraph 11.4.3 refer); and

b) the existing lighting specifications were adopted on the basis of extensive flight trials.

4.4.2.6 In light of the foregoing, the meeting agreed that before the VAP recommended any reduction in the length of the approach lighting pattern, the whole topic including pattern contents and beam spread characteristics should be further studied taking account of operational experience with both reduced pattern lengths and reduced RVR limits.

4.5 MAINTENANCE REQUIREMENTS FOR AERODROME LIGHTING SYSTEMS

4.5.1 The working group had concluded that there was a need to regulate inspections of aerodrome lighting systems and promote standardized procedures for measuring the characteristics of aeronautical ground lights included in such systems particularly at airports operating in low visibility conditions.

4.5.2 Experience from international airports with heavy traffic revealed that maintenance of visual aids and particularly the elements of the systems installed on or close to the runway was becoming increasingly more difficult. This was mainly due to the considerable increase of traffic in recent years on these airports and the resulting decrease in runway availability for maintenance purposes.

4.5.3 Up to the middle of the 1990's, the technology for on-site measurement of the photometric characteristics of aeronautical ground lights had certain limitations. As a consequence, some airport operators, rather than monitoring the photometric characteristics, conducted electrical measurements to evaluate the serviceability of lights. It was a well-known fact, however, that the accuracy of electrical measurement was not sufficient to cover the ranges between zero light intensity and the 50 per cent light intensity as required by ICAO. Electrical measurements could only be used to detect a simple breakdown of the circuitry. Therefore, in the interest of safety, the working group had concluded that airports should not monitor aeronautical ground lights based on simple electrical measurements.

4.5.4 With new technology, the lifetime of lamps in a luminaire had increased considerably. For example, an inset light on a busy commercial airport might have a lifetime of up to one year. Replacement of lamps were not normally undertaken in the field. Instead, the common practice was to replace the total light fixture. Maintenance action including cleaning, replacement of lamps etc. was conducted in the maintenance workshop. Previously, lamps had to be replaced after approximately 600 hours of usage. Modern lamp technology would allow lamps to be replaced after approximately 2 400 hours of usage. As a result, it had become necessary to undertake cleaning of lights in between replacement of lights.

4.5.5 Pollution caused by tyres could easily be identified by visual inspection. Other types of pollution resulting in a general reduction of the light intensity were not so obvious. In general, a visual inspection of an aerodrome lighting system had a very limited application and could not be used for the purpose of determining intensity, spread and orientation of the light beams. Consequently, a visual inspection could not be used for determining if a light unit was unserviceable according to Annex 14, Volume I definition.

4.5.6 Systems for automatic measurements of inset and sometimes elevated lights had been developed in many countries. Such systems included a vehicle that could conduct luminance measurements while moving or in stationary position. Experience indicated that, using such a vehicle, all the inset lights included in a category III runway lighting system could be checked within a time-frame of 30 minutes. The accuracy of systems evaluated in France was compatible with the precision required to determine whether a runway lighting system met the ICAO Standards. It was believed that, in the future, the accuracy as well as the efficiency of such systems would be further enhanced by the use of improved CCD camera and PC card techniques.

4.5.7 The conduct of periodic automatic measurement of lights for a whole runway was considered to only marginally increase the total cost of the maintenance of a category II or III runway system. In this context, the working group had recommended that, in order to minimize costs, the frequency of measurements should be limited to that required based on the local pollution level.

4.5.8 The meeting fully supported the conclusion of the working group that there was the need to regulate inspections of aerodrome lighting systems and promote standardized procedures for measuring the characteristics of aeronautical ground lights included in such systems particularly at airports operating in category II and III conditions. Accordingly, the meeting supported the related proposal for amendment to Annex 14, Volume I developed by the working group. In this context, the issue of frequency of inspections generated some discussion. The meeting recognized that, at major commercial airports, inspections would have to be scheduled at least twice a month. It was, therefore, considered that the proposed minimum frequency of twice a year might be misleading. On the other hand, at less busy airports subjected to little or no pollution, a frequency of twice a year might be adequate. The meeting agreed not to revise the proposed paragraph in the amendment proposal.

4.6 CONCLUSIONS

4.6.1 The meeting agreed that it had accomplished the assigned tasks under work programme Item 7 — Reduced lighting for precision approach runways. However, the meeting recognized that additional work would be required to determine the feasibility of further modification of approach and runway lighting configurations in order to meet future needs for all weather operations.

4.6.2 In light of the foregoing, the meeting formulated the following recommendations:

RSPP

Recommendation 4/1 — Amendment to Annex 14, Volume I — Reduced lighting for precision approach runways

That Annex 14, Volume I be amended as indicated in Appendix A to the report on this agenda item.

RSPP

Recommendation 4/2 — Amendment to Annex 14, Volume I — Maintenance requirements for aerodrome lighting systems

That Annex 14, Volume I be amended as indicated in Appendix B to the report on this agenda item.

Recommendation 4/3 — Modification of approach and runway lighting configurations

That ICAO task the Visual Aids Panel or an appropriate body of visual aids experts to study the possibility of further modifying the approach and runway lighting systems currently specified in Annex 14, Volume I for precision approach runways categories I, II and III (paragraph 6.5.1 refers).

STATEMENT BY MR. Y.F. KLENIN

In reference to Agenda Item 4, I wish to bring to the attention of the Air Navigation Commission my concern with the reduction of patterns of lighting currently specified in Annex 14, Volume I for precision approach runways categories II and III as proposed by the Visual Aids Panel.

My concern is caused by the rejection of the existing pattern of lighting systems on precision approach runways, which has proven itself in a positive manner, and the transition without sufficient substantiation to a simplified pattern without adopting adequate measures to maintain the required level of flight safety.

The existing precision approach category I, II and III lighting system scheme should be retained in Annex 14, Volume I, as a separate configuration and the simplified scheme should be given the status of a Recommended Practice.

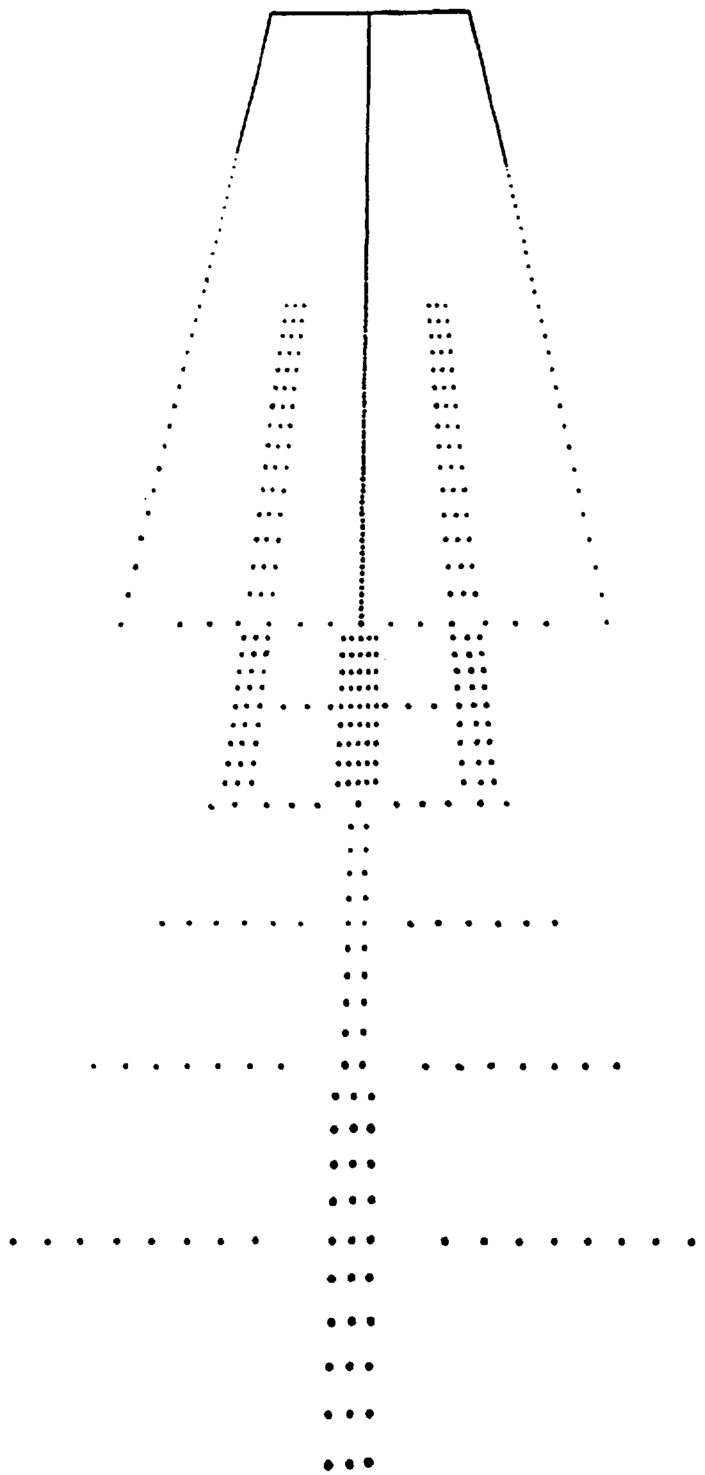

Figure 4-1. Current ICAO lighting pattern for precision approach runways categories II and III

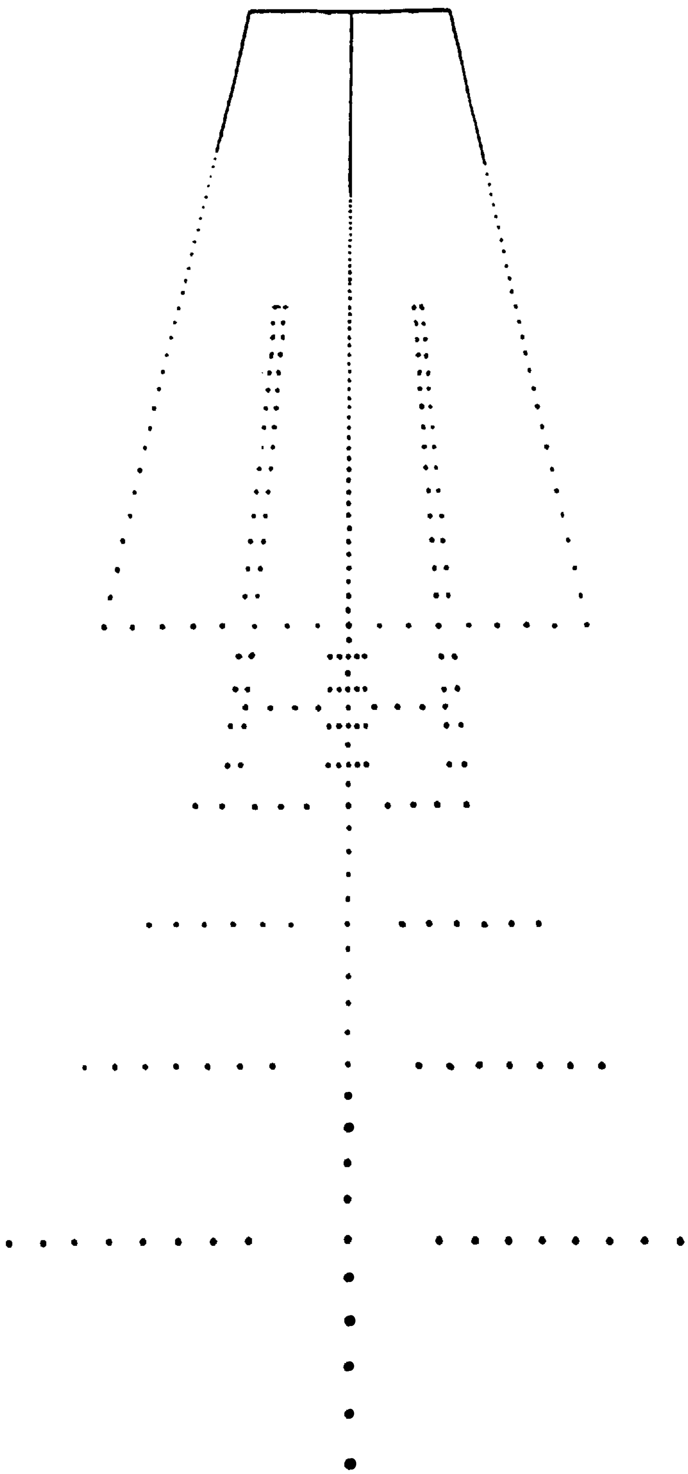

Figure 4-2. Reduced lighting pattern as proposed by the working group

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APPENDIX A

PROPOSED AMENDMENT TO

INTERNATIONAL STANDARDS AND RECOMMENDED PRACTICES

AERODROMES

ANNEX 14 TO THE CONVENTION ON INTERNATIONAL CIVIL AVIATION

VOLUME I (AERODROME DESIGN AND OPERATIONS)

NOTES ON THE PRESENTATION OF THE PROPOSED AMENDMENT TO ANNEX 14, VOLUME I

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CHAPTER 5. VISUAL AIDS FOR NAVIGATION

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5.3 Lights

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5.3.4 Approach lighting systems

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5.3.4.14 The centre line and crossbar lights of a precision approach category I lighting system shall be fixed lights showing variable white. Each centre line light station shall consist of either:

a) a single light source ~~in the innermost 300 m of the centre line, two light sources in the central 300 m of the centre line and three light sources in the outer 300 m of the centre line to provide distance information~~; or

b) a barrette at least 4 m in length.

. . . . .

5.3.4.20 The approach lighting system shall consist of a row of lights on the extended centre line of the runway, extending, wherever possible, over a distance of 900 m from the runway threshold. In addition, the system shall have two side rows of lights, extending ~~270 m~~ 240 m from the threshold, and two crossbars, one at 150 m and one at 300 m from the threshold, all as shown in Figure 5-8.

. . . . .

5.3.4.21 The lights forming the centre line shall be placed at longitudinal intervals of 30 m with the innermost lights located 30 m from the threshold.

5.3.4.22 The lights forming the side rows shall be placed on each side of the centre line, at a longitudinal spacing of 60 m ~~equal to that of the centre line lights and~~ with the first lights located ~~30 m~~ 60 m from the threshold. The lateral spacing (or gauge) between the innermost lights of the side rows shall be not less than 18 m nor more than 22.5 m, and preferably 18 m, but in any event shall be equal to that of the touchdown zone lights.

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Characteristics

5.3.4.28 The centre line of a precision approach category II and III lighting system for the first 300 m from the threshold shall consist of ~~barrettes showing variable white, except that, where the threshold is displaced 300 m or more, the centre line may consist of single light sources showing variable white. The barrettes shall be at least 4 m in length. When barrettes are composed of lights~~

~~approximating to point sources, the lights shall be uniformly spaced at intervals of not more than 1.5 m.~~ either:

a) barrettes, where the centre line beyond 300 m from the threshold consists of barrettes as described in 5.3.4.29 a); or

b) alternate single light sources and barrettes, where the centre line beyond 300 m from the threshold consists of single light sources as described in 5.3.4.29 b), with the innermost barrette located 60 m from the threshold; or

c) single light sources where the threshold is displaced 300 m or more;

all of which shall show variable white.

5.3.4.29 Beyond 300 m from the threshold each centre line light station shall consist of either:

a) a barrette~~ as used on the inner 300 m~~; or

b) ~~two light sources in the central 300 m of the centre line and three light sources in the outer 300 m of the centre line~~ a single light source;

all of which shall show variable white.

5.3.4.29A The barrettes shall be at least 4 m in length. When barrettes are composed of lights approximating to point sources, the lights shall be uniformly spaced at intervals of not more than 1.5 m.

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5.3.12 Runway centre line lights

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5.3.12.5 Runway centre line lights shall be located along the centre line of the runway, except that the lights may be uniformly offset to the same side of the runway centre line by not more than 60 cm where it is not practicable to locate them along the centre line. The lights shall be located from the threshold to the end at longitudinal spacing of approximately~~:~~ 30 m. Where the runway is used for operations in visibilities below 300 m RVR a longitudinal spacing of 15 m shall be provided.

~~— 7.5 m or 15 m on a precision approach runway category III; and~~

~~— 7.5 m or 15 m or 30 m on a precision approach runway category II or other runway on which the lights are provided.~~

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5.3.13 Runway touchdown zone lights

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5.3.13.2 Touchdown zone lights shall extend from the threshold for a longitudinal distance of 900 m, except that, on runways less than 1 800 m in length, the system shall be shortened so that it does not extend beyond the midpoint of the runway. The pattern shall be formed by pairs of barrettes symmetrically located about the runway centre line. The lateral spacing between the innermost lights of a pair of barrettes shall be equal to the lateral spacing selected for the touchdown zone marking. The longitudinal spacing between pairs of barrettes shall be ~~either 30 m or~~ 60 m.

~~*Note.— To allow for operations at lower visibility minima, it may be advisable to use a 30 m longitudinal spacing between barrettes.*~~

5.3.13.2A **Recommendation.—** *For operations in visibilities below 300 m RVR the longitudinal spacing between pairs of barrettes should be 30 m.*

Characteristics

5.3.13.3 A barrette shall be composed of at least three lights with a spacing between the lights of not more than 1.5 m.

5.3.13.4 **Recommendation.—** *A barrette should be not less than 3 m nor more than 4.5 m in length.*

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Editorial Note.— Revise Figure 5-8 as follows:

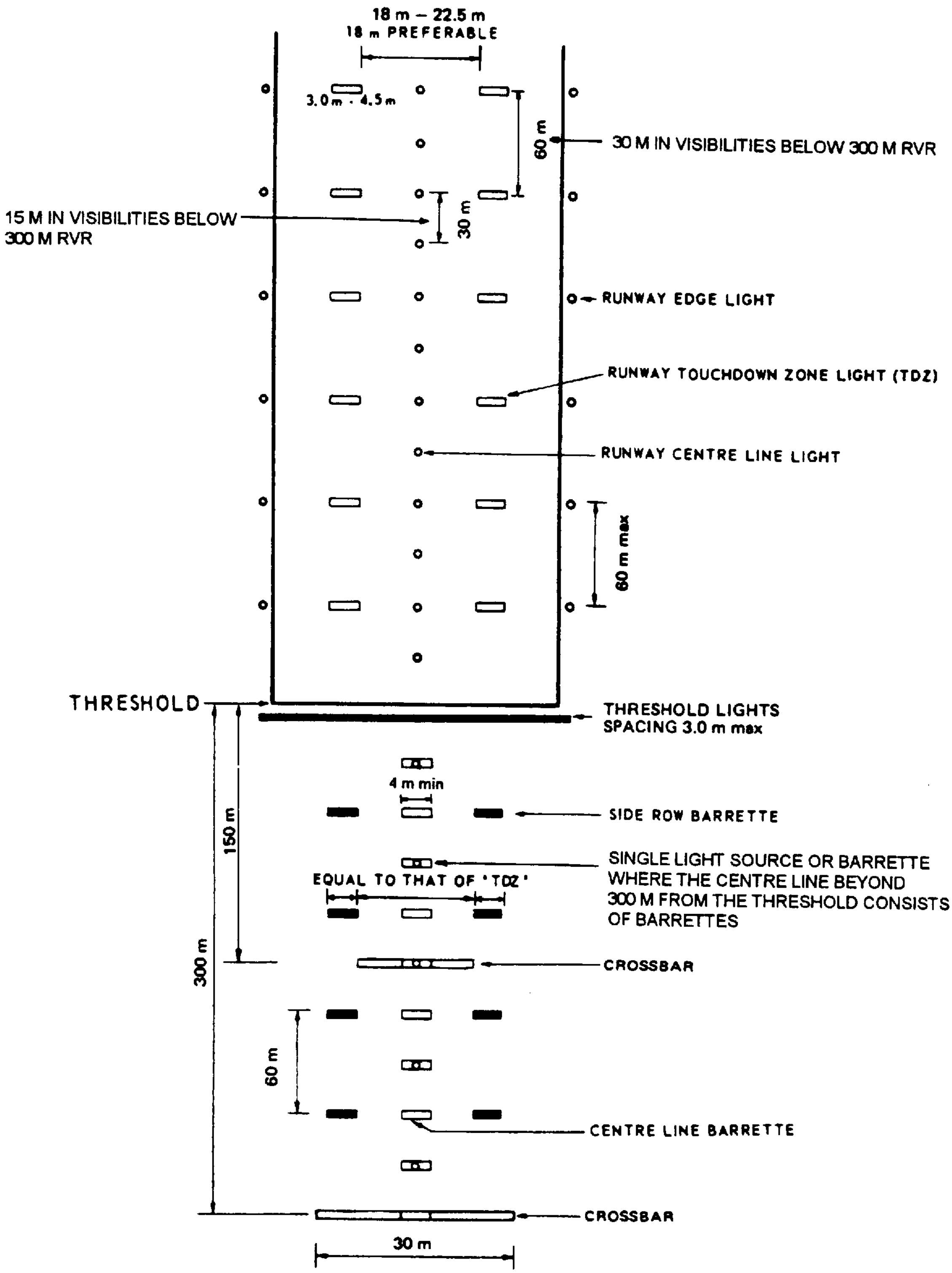

Figure 5-8. Inner 300 m approach and runway lighting for precision approach runways categories II and III

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CHAPTER 9. EMERGENCY AND OTHER SERVICES

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9.4 Maintenance

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Visual aids

9.4.20 A system of preventive maintenance of visual aids shall be employed to ensure lighting and marking system reliability.

Note. — Guidance on preventive maintenance of visual aids is given in the Airport Services Manual, *Part 9.*

9.4.20A The system of preventive maintenance employed for a precision approach runway category II or III shall include at least the following checks:

a) visual inspection and measurement of the intensity, spread and orientation of lights included in the approach and runway lighting systems;

b) control and measurement of the electrical characteristics of each circuitry included in the approach and runway lighting systems; and

c) control of the correct functioning of light intensity settings used by air traffic control.

9.4.20 In-field measurement of lights included in the approach and runway lighting systems shall be undertaken by measuring all lights, if practicable, or by measuring a selected number of lights based on statistical sampling.

Note.— Guidance on statistical sampling of lights is given in the Airport Services Manual, *Part 9.*

9.4.20C **Recommendation.—** *Measurement of lights included in approach and runway category II or III lighting systems should be undertaken using a mobile measuring unit of sufficient accuracy to analyze the characteristics of the individual lights.*

9.4.20D The frequency of measurement of lights shall be based on traffic density, the local pollution level and the reliability of the installed lighting equipment but not less than twice a year.

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PART II — REPORT ON AGENDA ITEM 5

Agenda Item 5: Measurement of light intensity/aeronautical ground lights

5.1 INTRODUCTION

5.1.1 The purpose of this agenda item was to:

a) review current Annex 14, Volume I, Appendix 2 specifications on computing the average intensity of steady burning lights;

b) develop specifications on computing the effective intensity of flashing lights for inclusion in Annex 14, Volume I, Appendix 2;

c) develop guidance material on standardized procedures for the measurement of intensities of steady burning and flashing lights for inclusion in the *Aerodrome Design Manual*, Part 4 — *Visual Aids*; and

d) update Annex 14, Volume I specifications on colours of lights using all forms of light filters (dyed-in-mass and dichroic).

5.1.2 The above tasks were developed based on recommendations formulated by the VAP/12 Meeting and are currently included in work programme Items 5 — Measurement of light intensity, and 9 — Colours for aeronautical ground lights.

5.1.3 The specifications on colours for aeronautical ground lights included in Annex 14, Volume I, Appendix 1, were last reviewed and updated in 1978 taking into account the then recommendations of the International Commission on Illumination (CIE). The CIE has recently updated its recommendations on colours for signal lights taking into account the advances in techniques for measurement of light colours. In view of this, it may be necessary to update the related specifications in Annex 14, Volume I. However, past experience indicates that the CIE recommendations, which have been developed for all applications, are not necessarily the most appropriate ones for use in international civil aviation. The CIE recommendations should, therefore, be reviewed and refined as necessary before including them in Annex 14, Volume I.

5.1.4 At the VAP/12 Meeting, the panel recognized the need to incorporate specifications on dichroic filters into Annex 14, Volume I. Accordingly, it formulated Recommendation 7/4 inviting ICAO to develop specifications on dichroic filters with the assistance of CIE. The Commission approved the recommendation and the CIE was invited on 3 March 1993, to assist ICAO in establishing such specifications. However, although the CIE responded affirmatively, little progress of work was seen. It was, therefore, proposed to the Commission that the Secretariat be permitted to accomplish this task with the assistance of the panel. The Commission endorsed this proposal and the task was included in the VAP work programme.

5.1.5 The panel considered that all the above tasks were interrelated and should be addressed together. It further believed that the tasks could be progressed most efficiently through an *ad hoc* group and, therefore, established the *Ad hoc* Group on Aeronautical Ground Lights to this end. The work of the *ad hoc* group has largely been advanced by correspondence. The results of this work, which included a proposal for amendment to Annex 14, Volume I as well as proposed guidance material for inclusion in the *Aerodrome Design Manual*, Part 4 — *Visual Aids* (Doc 9157), were presented at the meeting.

5.2 DISCUSSION

5.2.1 **1996 CIE chromaticity diagram**

5.2.1.1 National and international standards for visual signal lights usually specify requirements for the colours of light signals to ensure that the colours can be correctly identified. The previous official recommendations of the CIE provided sound guidance on the choice of these colours and were utilized in the drafting of most relevant standards.

5.2.1.2 The CIE first adopted recommendations for light signal colours in 1959. These were based on three experiments carried out in the 1930's and 1940's and on the technical and practical knowledge of the experts serving on the CIE committees that prepared the recommendations. Account was also taken of current practices and standards as well as the practical limitations of coloured signal glasses and signal assemblies and the need to generate signals of sufficient intensity.

5.2.1.3 The CIE recommendations are applicable to the colours of light signals used in sea, road, air and rail transport systems including the light signals on ships, motor vehicles, aircraft and trains.

5.2.1.4 Following new experimental work as well as experience in the application of the 1959 recommendations, a revision of the recommendations was published by the CIE in 1975 as CIE Publication 2.2 — 1975 Colours of Light Signals.

5.2.1.5 In 1987, the CIE saw the need for another revision based on further experimental work and changing needs and technology in visual signalling. There had been increased worldwide interest in operating machinery using colour coding for guidance and control. Therefore, Committee TC4-14 (Colours of Signal Lights) of CIE Division 4 (Lighting and Signalling for Transport) undertook a detailed analysis of the experiments on the recognition of light signals colours and consulted widely among the international experts on visual signalling.

5.2.1.6 The Committee reported its findings in CIE Technical Report 107, A Review of the Official Recommendations of the CIE for the Colours of Signal Lights, which was published by the CIE in 1994. This report contained details of relevant experiments, arguments regarding colour discrimination, recommendations and an extensive bibliography.

5.2.1.7 The Draft Standard CIE DS 004.2/E, Colours on Signal Lights had recently been adopted by the CIE Board of Administration and was in the process of being published as an official Standard.

5.2.1.8 The meeting was advised that the boundaries for colours of signal lights developed by the CIE was designed purely to discriminate colours. The design did not take into account the issue of recognition of colours which was of prime importance to colours of lights used for aviation. In general, the proposed new boundaries were more restrictive in order to meet the requirements of the population with abnormal colour vision. This resulted in a shorter visual range which in turn would require increased light intensities and higher supplied voltages. Thus, the introduction of the new colour boundaries for use in aeronautical ground lights would not only require a change of filters but would also affect the visual range of the lights, the operational requirements for power supply as well as the maintenance of the lighting systems.

5.2.1.9 The meeting was further advised that initial findings by one of the major manufacturers in the United States indicated that:

a) the proposed restrictions of chromaticity would severely hamper the productivity of airport lighting luminaires;

b) due to the dramatic shifts in colour under the wide range of power input, adhering to a limited colour box as proposed in the new CIE Standards would be impossible for all supplied voltages; and

c) adhering to the restricted colour boxes would severely change what is currently supplied to the industry and would possibly cause initial recognition problems to pilots and airport personnel as the change-over occurred.

5.2.1.10 On the other hand, a manufacturer in the United Kingdom had indicated that the use of dichroic filters might facilitate adherence to the new CIE Standard.

5.2.1.11 The meeting reviewed the need for revising the current colour boundaries for aeronautical ground lights included in Annex 14, Volume I, Appendix 1 at this point in time and concluded that:

a) colour coding of aeronautical ground lights would affect pilots as well as all airport personnel;

b) the colour coding should meet the requirements of the general population including those with abnormal colour vision;

c) the transition period would involve initial recognition problems due to possible mixing of colours based on different standards as well as practical problems related to the need for maintaining a supply of two different sets of light units;

d) the effect of the new CIE Standard on the recognition of colours particularly in relation to variation in light intensities had not been verified;

e) the shift in chromaticity due to increased temperature and power input effects resulting from the application of the new CIE Standard had not been examined; and

f) the safety benefits, if any, involved in the application of the new CIE Standard had not been verified.

5.2.1.12 Based on the above conclusions, the meeting agreed that, pending further studies on the subject, it would be premature to adopt the 1996 CIE Standards for specifications on colours for aeronautical ground lights. The meeting further agreed that such studies would have to take into account the broader perspective and the effect on the total system of a possible change-over from the currently applied Standard to the new CIE Standard. Accordingly, the meeting formulated Recommendation 5/1 to the report on this agenda item.

5.2.2 **Measurement of intensities of steady burning and flashing lights**

5.2.2.1 The panel had assigned a number of tasks to the *ad hoc* group. One of these tasks was the development of standard procedures for the measurement of intensities of steady burning and flashing lights. The *ad hoc* group, however, had concluded that Annex 14, Volume I, Appendix 2 sufficiently identified standards for light intensity and related procedures for the measurement of light intensities. The *ad hoc* group had, therefore, agreed that what was needed was the development of guidance material on the application of these standards and procedures. Such guidance material should provide the user with additional information, such as the use of grid points (Appendix 2, Figure 2.12 refers) to determine the average intensity for light units having a requirement of horizontal toe-in etc. Accordingly, guidance material had been developed by the *ad hoc* group for inclusion in the *Aerodrome Design Manual*, Part 4 — *Visual Aids* and submitted to the meeting for review.

5.2.2.2 The use of the Blondel Rey formula had been specified by the Illuminating Engineering Society (IES) of North America and was generally accepted for determination of effective intensity of flashing lights. However, there was no guidance as to when the intensity of a flashing light might be measured in the steady burning mode (with disablement of the flash mechanism). This subject had been studied by the *ad hoc* group and, as a result, guidance material had been developed for inclusion in the design manual.

5.2.2.3 The meeting briefly reviewed the guidance material developed by the ad hoc group and agreed, in principle, that this material would be suitable for inclusion in the design manual. The meeting, however, considered that further refinement as well as an overall editorial review of the material would be required.

5.2.3 **Specifications on colours of lights using all forms of light filters**

5.2.3.1 The issue of colour control and measurement was initially raised in relation to dichroic filters. However, the *ad hoc* group had concluded that the assurance of proper colour from light units should not be dependent upon the manner in which the colour was produced and that only the end result, which was the chromaticity, should be verified. Currently, there were dichroic and dyed-in-mass filters. However, LED and similar technologies were rapidly advancing and such technologies would most likely result in light signals using colours as well. Therefore, the *ad hoc* group had agreed that to concentrate on dichroic filters alone would tend to avoid focus upon the underlying issue applicable to any method of colour production.

5.2.3.2 The issue had been examined by the *ad hoc* group. The point of controversy had been with respect to the manner of verifying conformance to standards of colour, i.e. to which extent beyond the main beam colour was to be verified. Some members had suggested that the colour be measured well beyond the main beam. It was considered that this would be particularly important where the light unit would be used by pilots of B747 aircraft with a cut-off angle of 18 degrees. However, there was not enough consensus within the *ad hoc* group to recommend measurement of colour outside the main beam. The present practice, used by at least one State, was to take colour measurements at five points, *viz.* at the beam centre and at the vertical and horizontal limits of the main beam ellipse. It might be argued that, if the main beam was the basis for the operational use of the light unit, conformance to standards would then be of most importance in that particular location. On this basis, the *ad hoc* group had recommended that the main beam alone should be proposed as the location for colour measurement. Accordingly, the *ad hoc* group had developed a proposal for amendment to Annex 14, Volume I, Appendix 1.

5.2.3.3 The issue and the related amendment proposal generated considerable discussion in the meeting. Some members maintained that the operational needs had defined the isocandela diagrams in Annex 14, Volume I, Appendix 2 and that there was a need to also conduct measurements outside the main beam. On the other hand, it was recognized that dichroic filters might not be fully compliant in the outer regimes of the isocandela diagrams. Therefore, it was suggested that in these locations, rather than conducting measurements, it might be sufficient to verify by visual means that the colours did not fall significantly outside the boundaries. In conclusion, the meeting agreed on the following:

a) the colour of aeronautical ground lights shall be verified as being within the boundaries of Annex 14, Volume I, Appendix 1, Figure 1.1 by measurement at five points within the area bounded by the innermost isocandela curve (isocandela diagrams in Appendix 2 refer), with operation at rated current or voltage;

b) in the case of elliptical or circular isocandela curves, the colour measurements shall be taken at the centre and at the horizontal and vertical limits;

c) in the case of rectangular isocandela curves, the colour measurements shall be taken at the centre and the limits of the diagonals (corners);

d) in addition, the colour of the light shall be checked at the outermost isocandela curve to ensure that there is no colour shift that might cause signal confusion to the pilot;

e) for the outermost isocandela curve, a measurement of colour coordinates should be made and recorded for review and judgement of acceptability by the appropriate authority;

f) where light units may be viewed and used by pilots from directions beyond that of the outermost isocandela curve (e.g. stop bar lights at significantly wide runway-holding positions), the appropriate authority should assess the actual application and, if necessary, require a check of colour shift at angular ranges beyond the outermost curve; and

g) the signal colours for visual approach slope indicators and other light units having a colour transition sector shall be measured at points, as indicated above, except that the colour areas shall be treated separately and no point shall be within 0.5 degrees of the transition sector.

5.2.3.4 Accordingly, the meeting revised the proposal for amendment to Annex 14, Volume I, Appendix 1 developed by *ad hoc* group.

5.3 CONCLUSIONS

5.3.1 The meeting agreed that it had accomplished the assigned work under work programme Items 5 — Measurement of light intensity, and 9 — Colours for aeronautical ground lights. In light of the foregoing, the meeting formulated the following recommendations:

Recommendation 5/1 — 1996 CIE chromaticity diagram

That current specifications on colours of aeronautical ground lights included in Annex 14, Volume I, Appendix 1 be retained pending further studies on the total effect of replacing these specifications by the new CIE Standard.

RSPP **Recommendation 5/2 — Amendment to Annex 14, Volume I — Measurement of light intensity/aeronautical ground lights**

That Annex 14, Volume I be amended as indicated in Appendix A to the report on this agenda item.

Recommendation 5/3 — Amendment to the *Aerodrome Design Manual*, Part 4 – Visual Aids (Doc 9157)

That the *Aerodrome Design Manual*, Part 4 be amended as indicated in Appendix B to the report on this agenda item.

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APPENDIX 1. AERONAUTICAL GROUND LIGHT AND SURFACE MARKING COLOURS

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2. Colours for aeronautical ground lights

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2.2 Discrimination between lights

2.2.1 **Recommendation.—** *If there is a requirement to discriminate yellow and white from each other, they should be displayed in close proximity of time or space as, for example, by being flashed successively from the same beacon.*

2.2.2 **Recommendation.—** *If there is a requirement to discriminate yellow from green and/or white, as for example on exit taxiway centre line lights the y coordinates of the yellow light should not exceed a value of 0.40.*

Note.— The limits of white have been based on the assumption that they will be used in situations in which the characteristics (colour temperature) of the light source will be substantially constant.

2.2.3 **Recommendation.—** *The colour variable white is intended to be used only for lights that are to be varied in intensity, e.g. to avoid dazzling. If this colour is to be discriminated from yellow, the lights should be so designed and operated that:*

a) the x coordinate of the yellow is at least 0.050 greater than the x coordinate of the white; and

b) the disposition of the lights will be such that the yellow lights are displayed simultaneously and in close proximity to the white lights.

2.2.4 The colour of aeronautical ground lights shall be verified as being within the boundaries of Figure 1.1 by measurement at five points within the area bounded by the innermost isocandela curve (isocandela diagrams in Appendix 2 refer), with operation at rated current or voltage. In the case of elliptical or circular isocandela curves, the colour measurements shall be taken at the centre and at the horizontal and vertical limits. In the case of rectangular isocandela curves, the colour measurements shall be taken at the centre and the limits of the diagonals (corners). In addition, the colour of the light shall be checked at the outermost isocandela curve to ensure that there is no colour shift that might cause signal confusion to the pilot.

Note 1.— For the outermost isocandela curve, a measurement of colour coordinates should be made and recorded for review and judgement of acceptability by the appropriate authority.

Note 2.— Certain light units may have application so that they may be viewed and used by pilots from directions beyond that of the outermost isocandela curve (e.g. stop bar lights at significantly wide runway-holding positions). In such instances, the appropriate authority should assess the actual *application and if necessary require a check of colour shift at angular ranges beyond the outermost curve.*

2.2.5 In the case of visual approach slope indicators and other light units having a colour transition sector, the colour shall be measured at points in accordance with 2.2.4, except that the colour areas shall be treated separately and no point shall be within 0.5 degrees of the transition sector.

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APPENDIX B

(In English only)

NEW CHAPTER 9A IN THE *AERODROME DESIGN MANUAL*, PART 4 — *VISUAL AIDS*

Insert the following new Chapter 9A in the *Aerodrome Design Manual*, Part 4 - *Visual Aids*

Chapter 9A. MEASUREMENT OF INTENSITY FOR STEADY BURNING AND FLASHING LIGHTS

1. INTRODUCTION

1.1 Aeronautical ground lights, with the exception of guidance sign luminaires, commonly provide a point source signal that is viewed by aircraft, either at great distances whilst proceeding to a landing (e.g. approach and runway lights) or at relatively close distances for manoeuvring guidance on the airfield (e.g. taxiway lighting). In both instances, Annex 14, Volume I, Appendix 2 specifies these lights in terms of luminous intensity or candelas, and the method of specification is through the use of isocandela diagrams. In addition, other applicable criteria is to be found in the main body of the Annex.

1.2 When selecting lights for installation on site, conformance to the pertinent specification will have to be ensured. This assurance may be obtained either through attestation by an accredited laboratory or from a manufacturer having accredited facilities and procedures. Third party accreditation is covered by ISO standards.

1.3 Whichever the source, the manner of assurance comes down to the fundamental activity of measuring the intensity of the light unit. Techniques of measurement and quality of measurement and equipment (e.g. detectors, goniometers etc.) are well described in other reference sources. Thus, the purpose of this guidance material is to detail criteria which are specific to aerodrome applications. This involves the distance of measurement, the calculation of average intensity, conformance to minimum and maximum values within the main beam, conformance to minimum values within the outer isocandela boundaries, tolerances, etc. In the case of lights that have a flashing characteristic, description is given herein (Section 3 refers) for the method of calculating effective intensity which is defined as the intensity equivalent to that of a steady burning light to produce the same visual effect for the eye.

2. CRITERIA

2.1 Distance of measurement

2.1.1 Aeronautical ground lights come in many forms with respect to the longest dimension of the luminous source and the number of sources that may be used to create a signal. For the purpose of accuracy of measurement and standardization, it is recommended that the distance of measurement should not be less than 20 m for single light sources and not less than 30 m for multiple light sources, such as high-intensity obstacle lights and visual approach slope indicators.

2.2 Set-up

Aging of lamps

2.2.1 Attention must be taken to ensure that the lamp will be operating with expected emission. Therefore, prior to conducting measurements, the lamp should be aged to at least 1 per cent of their rated life. In the case of fluorescent or other lamp types, reference should be made to the lamp manufacturer. The lamp should also be stabilized photometrically, such that an initial measurement in a given direction is maintained constant within approximately ± 1 per cent.

Reference axis

2.2.2 The light unit should be set up on the goniometer in such a way that the reference axis will replicate the actual installation. For example, in the case of runway edge lights the axis is defined as that between the filament and detector and should be such that the detector is located as if placed in the line of light units along the edge of the runway. This will establish what may be referred to as the mechanical centre, rather than the luminous beam centre, which might involve rotation of the goniometer until finding a point of highest intensity and then taking measurements around this point. If the light unit is set up on the basis of the luminous beam centre, then any specified horizontal toe-in angle will not verified, since the photometric centre of the beam may not necessarily be the point of highest intensity. For runway and taxiway light units, the horizontal axis runs through the centre of the light unit and is parallel with the centre line. The vertical axis runs through the centre of the light. The manufacturer should be consulted for proper placement and orientation of the lamp within the light unit.

2.2.3 In the case of inset lights, the output at the lower edge of the beam will be dependent upon the manner of actual site installation. Some manufacturers may recommend in their instruction manuals, that the light unit should be installed at some distance below the surrounding pavement so as to lower the profile and thus avoid damage from snowplows. If this is the case, then the set-up should include some means to simulate the expected elevation of the pavement as this will tend to obstruct a portion of the lower edge of the beam. Although pavements normally have a slope which could impede light output (e.g. light channels orientated perpendicular to the centre line), for the purpose of laboratory testing the pavement should be considered as a horizontal plane without any slope.

2.2.4 Every attempt should be made to ensure that the reference axis is true and does not incorporate an horizontal offset or a vertical error for the height of the filament (elevated lights). In the case of inset lights, the horizontal orientation is established by symmetry of the unit. Where the inset light is bi-directional and optical windows are offset from each other, this offset can be ignored, considering the distance of measurement. The horizontal and vertical positioning of the light unit should be checked with a suitable spirit level within an accuracy of ± 0.1 degrees.

2.2.5 The measured light intensities should be corrected with respect to the rated nominal luminous output of the lamp as specified by the manufacturer. For example, a light unit may be found to produce an intensity of 14 000 candela for a luminous output of 2 800 lumens. If the manufacturer publishes a rating of 2 400 lumens, then the intensity should be corrected as follows and retained for the compliance record.

14 000 candelas * (2 400/2 800) = 12 000 candelas

Number of tests

2.2.6 At least 5 lights should be tested with different lamps. The corrected results (paragraph 2.2.5 refers) should not have a significant variation of value. That is, there should be a consistency of results demonstrating that the light unit design performance is repeatable for the production line.

Colour Measurement

2.2.7 The colour of the light unit should be verified, when operating at rated current or voltage, as being within the chromaticity boundaries of Annex 14, Appendix 1, Figure 1.1 for the horizontal and vertical limits of the main beam (in the case of elliptical or circular isocandela curves) or the limits of the diagonals of the main beam (in the case of rectangular isocandela curves). Furthermore, the colour should be checked by measurement at similar limits for the outermost isocandela curve. This latter check is to ensure that there is not an unacceptable colour shift for angles of observation. If for this latter test the colour shifts outside the chromaticity boundaries, the site authority should be consulted for judgement of the acceptability of the amount of colour shift.

Note.— The above-mentioned check of colour shift might be specified by the appropriate authority to be conducted beyond the outermost isocandela curve, for procurement of light units that have application where the angle of observation by the pilot is at a much larger range (e.g. stop bars at inordinately wide runway entrances).

2.3 Isocandela diagram

2.3.1 Measurement for conformance to the isocandela diagram involves a number of criteria. The first step is to obtain the intensities at spatial points over the horizontal and vertical ranges, as indicated by the grid of the applicable isocandela diagram. For example, in the case of a an elevated runway edge light (Annex 14, Volume I, Appendix 2, Figure 2.11 refers), the beam centre shall have an elevation angle 3.5 degrees vertical. Furthermore, a note is provided beneath the diagram stating a toe-in angle of 4.5 degrees horizontal. It is of importance to realize that some lights have a toe-in angle, as that this is not indicated on the diagram itself, since the latter serves only to illustrate the distribution around a theoretical beam centre. The light unit should be measured over a horizontal range that includes the toe-in.

2.3.2 For the given example, the outer boundary (5 per cent) has a range of ±10 degrees. It is suggested that in order to verify the location of the main beam and to allow for latter application of tolerances, that the actual measurement be done with an extension of at least 2 degrees. Thus, the horizontal ranges would be 10+2+4.5=16.5 or 17 degrees to 10+2-4.5=7.5 or 8 degrees. In the isocandela diagram, the outer boundary has an upper vertical limit of 12 degrees and the lower edge the main beam is zero degrees. In order to allow later application of tolerances it is suggested that the actual measurements be done over a range of 12+2=14 degrees and 0-2=2 degrees.

2.3.3 Although the calculation of average intensity, as discussed below, is based upon values at one degree increments, the actual measurement should be done at half degree increments. This will enable assessment of light units, whose theoretical beam centre toe-in, and/or elevation angles that are fractional numbers (e.g. 4.5 and 3.5 degrees respectively) as well as the application of tolerances.

Average intensity

2.3.4 Annex 14, Volume I, Appendix 2, Figures 2.12 and 2.18 indicate the grid nodes, at which measured intensities are to be incorporated into a calculation of average intensity.. In the case of a runway edge light, the boundary is elliptical in shape and the pertinent nodes are to be found within the main beam except for horizontal and vertical limits. In the case of taxiway centre line lights, the boundary is rectangular, so that nodes along the boundary are included if this boundary is on a grid line. The average intensity is calculated as the sum of all the intensity measurements of the identified notes divided by the number of measurements.

2.3.5 In Figure 2.12, the horizontal limits of the main beam are at ±6.5 degrees. Therefore, some grid points are not included in the calculation of average intensity. However, this figure is a typical illustration of method and whether the measurements at certain grid points are to be included in the calculation of average intensity depends upon the amount of toe-in. For example, a fraction value of toe-in (e.g. 4.5 degrees), will shift the figure so that the extremities of the ellipse reach a line of the grid and thus these measurements at these points would be included in the calculation.

Minimum and maximum values

2.3.6 It is intended that the beam shall have a certain uniformity without significant low or high intensities. Therefore, in accordance with Annex 14, Volume I, paragraphs 5.3.1.11 and 5.3.1.12 within and on the boundary of the main beam, the individual intensities are required to be not less than minimum which is half the average intensity and not more than a maximum which is three times the minimum. In effect, a uniformity ratio such that the individual intensities are to be with ±50 per cent of the average. For example, if the measured average intensity is 240 candelas, then the minimum is 120 candelas and the maximum 360 candelas.

Minimum Values for Outer Boundaries

2.3.7 It is also intended that the photometric distribution should be continued in a uniform fashion to the outer boundaries. Thus, the outer boundaries are identified my minimum values of intensity. On and within these boundaries, the individual intensities should not be less than the identified values.

Tolerances

2.3.8 In determining the conformance to average intensity and minimum values of the outer boundaries, the grid may be shifted ±1.0 degree horizontally and ±0.5 degree vertically. The grid should be shifted only once for a particular direction. It is not intended that the isocandela curve would be reduced in angular range.

Note.— The above proposed tolerances were controversial and were not accepted by the ad hoc group reviewing the issue during the VAP/13 Meeting.

Omnidirectional light units

2.3.9 In the case of omnidirectional light units, measurement of intensity should be made for a grid of one degree increments vertical and 30 degree increments horizontal. For each vertical scan, the measured values should meet the minimum requirement and the calculated average of these values should meet the minimum average intensity value. The light unit should be inspected for the presence of any internal supports or other structures that might cause an obstruction of light output. Where there is a possibility of obstruction, the reduction of intensity within the one degree, should not be less than 75 per cent of the minimum.

Note.— For omnidirectional low intensity lights, a lower photometric distance might be used. The distance, however, should be sufficiently great so that the inverse square law applies. That is, it should be greater than 20 times the largest dimension of either the light source or the acceptance area of the photometer head, but should not be less than 3 m.

Site standard

2.3.10 Although there is stipulation for a uniformity ratio of maximum and minimum values within the main beam, this is solely based upon the requirement of average intensity which is of itself a minimum requirement. All other required values outside the main beam are also minimums. Thus a light unit may be found in conformance should it significantly exceed the required average intensity and minimums. There is no overall maximum which limits the allowable output. Thus, assuming a requirement of 200 candela average (for example Annex 14, Volume I, Appendix 2, Figure 2.13), a light unit may be deemed as being in conformance, if its average intensity just meets this requirement or is significantly in excess of the requirement, as long as these lights each have a uniformity ratio of ±50 per cent within the main beam. If all available light units deemed to be in conformance with Annex 14, Volume I are treated equally for procurement, there is a potential of imbalance of display from one lighting system to another of the same type. For example, if we take the afore-mentioned example, and an installation is done with light units just meeting the 200 candela average requirement, a further procurement of units having a 600 candela average will immediately create an imbalance of display of 3 to 1. If the former units are repaired on the basis of occurrence of failure to half the original output (down to 100 candelas) and the latter are still in full operating condition, the imbalance can be of the order of 6 to 1. Thus, the site should be aware of the level of light output from units of its first procurement. This establishes a site standard and future procurements for installation of new lighting systems or for replacement of existing light units should be of the same level within a ratio of at least 2 to 1 for runway light units and 2.5 to 1 for taxiway light units..

3. FLASHING LIGHTS

3.1 It is generally recognized that when a light signal consists of separate flashes, the instantaneous intensity during the flashes must be greater than the intensity of steady burning light in order to obtain threshold visibility. Blondel and Rey found that the threshold illumination for an abrupt flash (a flash producing a relatively constant illuminance throughout its duration) is :

$$E = Eo\frac{a+t}{t} \qquad (1)$$

where Eo is the threshold illuminance for a steady burning light, t is the flash duration, and a is a constant equal to 0.21 when t is in seconds.

3.2 It is convenient to evaluate flashing lights in terms of their effective intensity such that the intensity of a steady burning light which will appear equally bright. Then

$$Ie = \frac{IEo}{E}$$

where I is the instantaneous intensity producing the illuminance E

and for an abrupt flash of constant illuminance

$$Ie = \frac{It}{a+t} \qquad (2)$$

3.3 The intensity of airport flashing lights, however, is not abrupt but rises and falls gradually and may vary appreciably during the flash. If the flash duration is very short, or if the times of rise and fall of intensity are short in comparison to the flash duration, only small uncertainties would be introduced in the determination of flash duration by the product of the peak intensity and the flash duration for the quantity It. However, in many cases significant errors would be introduced and some modification of equation (2) is necessary.

3.4 Some of the applications for flashing lights have evaluated their signals in terms of candela–seconds in the flash, integrating over the period of not more than 0.5 seconds, that is

$$Candela\text{-}seconds = \int_{t1}^{t2} I\,dt$$

where I is the instantaneous intensity and t_2-t_1 does not exceed 0.5 seconds.

3.5 When the specification for aircraft anti-collision lights was being drafted, it was suggested that equation (2) be modified so that

$$Ie=\frac{\int_{t1}^{t2} Idt}{0.2+t2-t1} \qquad (3)$$

3.6 Rather than to use an arbitrary set of limits, such as choosing for t_1 and t_2 the times when I is 10 per cent of the peak intensity of the flash, a choice is made which would obtain Ie a maximum when the limits of t_1 and t_2 are the times when the instantaneous intensity is equal to Ie. Since both the instantaneous intensity I and the times t are unknown, this leads into a process of repeated calculations to maximize Ie. It is of importance to note that the times t1 and t2 are not the times at the exact beginning and at the exact ending of the flash, but some period later and before respectively in order to maximize Ie.

3.7 The process for calculation of Ie is as follows:

a) The end result of the calculation will be to obtain the value Ie (as shown in Figure X below) for which Ie is equal to the instantaneous intensity at the times t_1 and t_2. That is, Ie = I.

b) Assume that the first trial of selecting a possible value of Ie is I". The time period is then t''_1 to t''_2 which includes t_1 to t_2. The calculated intensity, however, will be found to be greater than I". Therefore, the actual effective intensity Ie must also be greater than I", but its exact value remains unknown.

c) Another value of trial intensity I' is selected with associated time limits of t'_1 and t'_2. This results in a calculated intensity which is less than I'. Therefore, the actual effective intensity must be less than I'. Yet, its actual value still remains unknown.

d) Since a modification of times chosen as the limits in equation (3) changes the denominator and numerator in the same direction, the selection of times and calculation is a matter of repeating the steps as often as necessary to obtain the desired accuracy.

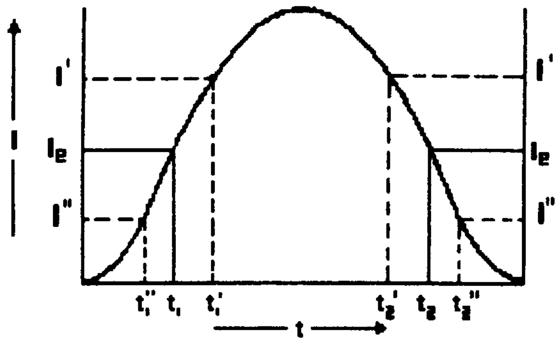

Figure X

3.8 Figure X indicates the process to determine conformance of the flashing light to a specified effective intensity Is. Here the actual effective intensity is indicated as Ie. The first step is to calculate the initial effective intensity Ie_1 using the time limits corresponding to the specified effective intensity Is. Referring to Figure X(a), if the calculated Ie_1 is found to equal or exceed Is, the light unit conforms, since the actual effective intensity Ie must lie above this. Referring to Figure X(b), if the first calculated Ie_1 lies below the specified intensity Is, then the actual Ie is still unknown and may be less than Is. Therefore, a repeated calculation is made to confirm the value of Ie is indeed less than Is.

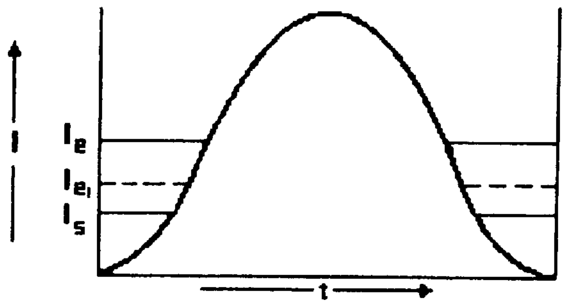

Figure X(a)

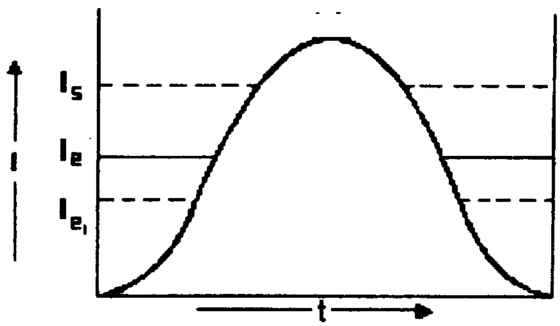

Figure X(b)

3.9 The calculation can be simplified where the flash duration is less than one millisecond, in which case the value of $(t_2 - t_1)$ is minimal, such that $[0.2 + t_2 - t_1]$ tends towards 0.2 seconds and the effective intensity is then found from the equation:

$$Ie = \frac{\int Idt}{0.2} = 5 * \int Idt \qquad (4)$$

where Idt is integrated over the entire flash cycle.

In this instance, Ie can be measured directly using an integrating detector to find the candela seconds [integral of Idt] of the result multiplied by 5.

3.10 The signal from a flashing light may consist of regularly spaced single flashes of light, as shown in Figure X, and the interval between flashes is so great that each flash has little influence on the effective intensity of the adjacent flashes. If the threshold intensity required to make a steady burning light visible is much less than Ie, the flash will be seen as a continuous flash with two peaks. However, if the threshold intensity is about equal to Ie, two separate flashes will be seen. The maximum distance at which the light can be seen will be determined by the effective intensity of a single flash computed over the time interval t_1 to t_2.

3.11 Certain lights produce a number of very short flashes in rapid succession so that this group of flashes is seen as a single flash. If in a group of flashes, as shown in Figure Y, the periods, during which the instantaneous intensity of the light is below the effective intensity of the flash, are of the order of 10 milliseconds or less, the eye will perceive this group as a single flash.

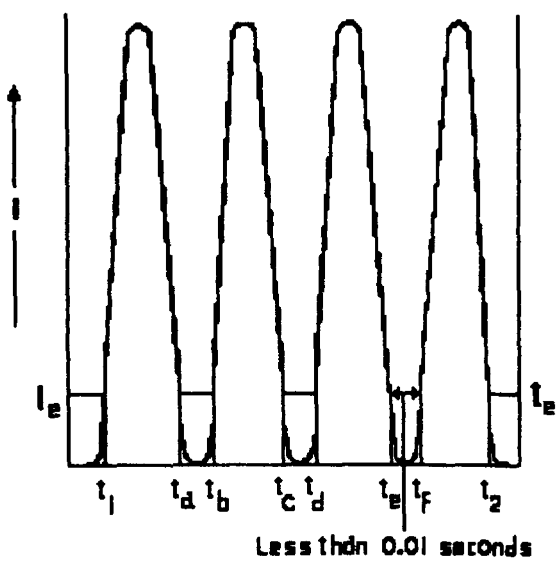

Figure Y

3.12 The effective intensity should then be computed by equation (5), choosing as times t_1 and t_2 the first and the last times the instantaneous intensity is Ie. Note that Ie is the effective intensity of the group and not that of a single flash.

$$Ie = \frac{\int_{t1}^{ta} Idt + \int_{tb}^{tc} Idt + \int_{td}^{te} Idt + \int_{tf}^{t2} Idt}{a + (t2 - t1)} \qquad (5)$$

3.13 Experience indicates that if the times chosen for the initial integration are the times when the instantaneous intensity is about 20 per cent of the peak intensity, only one additional step is required to obtain the value for the effective intensity which is within one or two per cent of the maximum value. This is within the limits of accuracy with which the integral is evaluated by means of a planimeter. Often a single computation is sufficient if, instead of using as limits for the initial integration the times when Ie is 20 per cent of the peak intensity, the times used are the times when the instantaneous intensity is equal to the product of the peak intensity and the number of seconds between the times when the instantaneous intensity is roughly 5 per cent of the peak intensity.

Transition to steady burning measurement

3.14 For some lights, the time duration of flash can be sufficiently long that the error is not significant if the flashing mechanism is disabled and the intensity is measured with the light operating in the steady burning mode. This would be the case when the time duration of flash is more than 200 ms (0.2 seconds). Thus, runway guard lights, certain rotating aerodrome beacons, medium-intensity red incandescent obstacle lights, etc. may be measured as steady-burning.

Measuring method

3.15 Flashing light units, with the exception of runway guard lights, are not specified in Annex 14, Volume 1, by means of isocandela diagrams. Therefore, the measurement of intensities involves a verification to minimum requirements at specified spatial points and minimum vertical beam spreads. In addition, for capacitor discharge light units:

a) testing should be conducted with the maximum length and actual size of cable as would be used for the most critical installation;

b) the measurement should begin after 10 minutes of operation;

c) the flash failure rate should not be more than 1 in a 100; and

d) the discharge can be somewhat unstable such that the peak intensity is not exactly repeatable for each flash. Thus, measurement for a sequence of short individual flashes should be made by averaging over at least 5 flashes to obtain an average value of candela seconds and then multiplying this result by 5.

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PART II — REPORT ON AGENDA ITEM 6

Agenda Item 6: Future work

6.1 INTRODUCTION

6.1.1 The purpose of this agenda item was to:

a) review the need for further work on visual aids for visual alignment systems for heliports and runways;

b) catalogue unresolved issues of the current work programme;

c) identify new tasks related to visual aids on which work would need to be undertaken in the near future; and

d) recommend alternative courses for accomplishing future work.

6.2 VISUAL ALIGNMENT GUIDANCE SYSTEMS

6.2.1 General

6.2.1.1 The current work programme of the panel included the following items related to the development of visual alignment guidance systems:

Item 1 — Visual aids for heliports (envisages the development of specifications for a standard visual alignment guidance system).

Item 8 — Visual alignment guidance system for runways (alignment guidance to a runway where it is physically impossible to install an approach lighting system).

6.2.1.2 As Items 1 and 8 were similar in nature, it seemed best to handle them together. Accordingly, the panel agreed to revive the defunct Working Group on Visual Aids for Helicopter Operations to address the two issues. The working group held one informal meeting.

6.2.2 Visual alignment guidance system for heliports

6.2.2.1 The issue originally formed part of VAP's work programme. At the VAP/12 Meeting, the panel was unable to agree on a single visual alignment guidance system for heliports. It, therefore, developed specifications defining the basic characteristics of such systems. These specifications were subsequently incorporated into the Second Edition of Annex 14, Volume II.

6.2.2.2 In their reply to the State letter seeking views on the need for a standard system, twenty-five States considered it necessary to identify a standard system, twelve States saw no need for such a system and three States had no position. The Kingdom of the Netherlands emphasized that the general specifications developed at VAP/12 would lead to proliferation of different types of system and that this situation would not be desirable from the standpoint of safety. The Kingdom of the Netherlands also favoured the adoption of a system used in France as world standard. This system was reviewed at the VAP/12 Meeting.

6.2.2.3 At its informal meeting held in November 1995, the working group reviewed the developments on the subject. Prior to VAP/12, work on the development of visual alignment guidance systems had mostly been undertaken in France. The French member of the working group had advised that work on the development of such systems had seen little progress in France since VAP/12. Furthermore, none of the other members were aware of any evaluations or programmes in their respective States regarding the development of such systems.

6.2.2.4 In view of the above, the working group had concluded that a single system for worldwide use could not be developed in the near future. The working group had, therefore, recommended that the Secretariat monitor developments on the subject and that Item 1 be deleted from the VAP work programme until such time as further work on the development of a standard system had been undertaken by States.

6.2.2.5 The meeting endorsed the above recommendations of the working group.

6.2.3 **Visual alignment guidance system for runways**

6.2.3.1 The responses to the State letter seeking views on the need for a visual alignment guidance system for runways showed minority support (15:21) to develop such a system. The proponents indicated that the system would be beneficial:

a) where conditions precluded or made it prohibitive in cost to install an approach lighting system;

b) where other approach aids were not available;

c) on runways having non-precision approach procedures (without localizer);

d) where roll guidance was required to be provided;

e) where noise abatement procedures were used;

f) where obstacles were present on either side of the approach path; and

g) where the traffic volume did not justify the cost of an approach lighting system.

6.2.3.2 At its informal meeting, the working group generally agreed that there was no need to extend the provision for visual alignment guidance systems to runways. None of the members of the working group were aware of any evaluations or programmes in their respective States regarding the development of such systems for runways. The members, therefore, had concluded that there was little requirement seen for these systems and that the runway lighting and runway lead-in lighting systems provided sufficient means for visual alignment guidance. Accordingly, the working group had recommended that Item 8 be deleted from the VAP work programme.

6.2.3.3 The meeting endorsed the above recommendation of the working group.

6.3 UNRESOLVED ISSUES OF THE CURRENT WORK PROGRAMME

6.3.1 The meeting concluded that further work on the following issues of the current work programme of the panel would be required:

a) apron marking;

b) co-ordinate the development of visual aids to meet the requirements of advanced surface movement guidance and control systems (A-SMGCS);

c) develop specifications where necessary for visual aids to control movements on airports in response to A-SMGCS including variable message signs and selective switching of taxiway centre line lighting; and

d) updating the *Aerodrome Design Manual*, Part 5 — *Electrical Systems* (Doc 9157).

6.3.1.1 In addition, the meeting noted that, once operational requirements for the planning and implementation of land and hold short operations for worldwide application had been developed by ICAO, further work on the development of visual aids for such operations might be required.

6.3.1.2 As regards updating the *Aerodrome Design Manual*, Part 5, under Agenda Item 2, the meeting had recommended that no further work be undertaken on the manual pending completion of the IEC Standards and guidance material related to design and monitoring of electrical systems for aeronautical ground lights (paragraph 2.3.5.1 refers).

6.4 NEW TASKS RELATED TO VISUAL AIDS

6.4.1 Switching of lighting aids

6.4.1.1 All the visual aids specified in Annex 14, Volumes I and II provides a fixed signal through the use of markings and lights. Lighting control is limited to the selection of light levels. The only exception is the stop bar that is specified at holding positions in low visibility conditions. At present, even the use of this very specific switching function is resisted in many States.

6.4.1.2 There is an urgent need to address the issue of switching of lighting aids used for guidance and control in ground movements. Unless this issue is resolved so that lighting aids can be switched, there is little scope for development in future visual aids.

6.4.1.3 The use of selective switching and variable messages, supported by computer-based management facilities, is a desirable option for the future. Not only will such technologies widen the scope for much needed visual aids, they will also enable some current human factors anomalies to be resolved. For example, at present pilots are required to taxi past mandatory hold signs/markings which are not applicable.

6.4.1.4 The issue of switching of lighting aids would be addressed by the panel under the existing task on visual aids for A-SMGCS.

6.4.2 Inconsistency in Annex 14, Volume I switch-over time requirements for the barrette centre line type precision approach lighting system

6.4.2.1 There is an inconsistency in the Annex 14, Volume I, Table 8-1 related to the barrette centre line type precision approach categories II/II lighting system. The table specifies a maximum switch-over time of 15 seconds for approach lighting systems and 1 second for supplementary approach lighting barrettes. In developing these specifications, the VAP/12 had considered that the inner 300 m of approach lighting, which consisted of the centre line and crossbars at 150 m and 300 m, could be lost without any operational penalty provided that the supplementary white and red approach lighting barrettes remain lighted. As regards the barrette centre line type precision approach lighting system, the white barrettes already exists in the category I configuration and the supplementary category II/III lights are limited to the red barrettes and a white crossbar at 150 m. Therefore, the VAP/12 rationale is not applicable to the barrette centre line type precision approach lighting system and the Table 8-1 specifications should be amended, as required.

6.4.3 Review of the "main beam" concept

6.4.3.1 In Annex 14, the beam characteristics are specified by means of isocandela diagrams (Annex 14, Volume I, Appendix 2, Figures 2.1 to 2.21 and Annex 14, Volume II, Figure 5-9 refer). In the earlier editions of the Annex, beam characteristics were specified by tables and beam spreads. For each light, the innermost high-intensity part of the beam was specified by a horizontal and a vertical beam spread. This part of the beam was referred to as the "main beam".

6.4.3.2 As a result of the use of the term "main beam" in the beam spread tables, the term was used throughout the Annex when referring to beam characteristics. With the introduction of isocandela diagrams in the Annex, it is no longer considered appropriate to use that term and, therefore, the "main beam" concept in general should be reviewed.

6.4.4 Design and monitoring of electrical systems/reliability of aerodrome lighting systems

6.4.4.1 There is a need for an overall review and updating of Annex 14, Volume I requirements related to design and monitoring of electrical systems as well as reliability of aerodrome lighting systems. In particular, further development of specifications related to air traffic control interface and visual aids monitoring will be required. In this context, the need for switching of lighting aids used for guidance and control in future A-SMGCS will have to be taken into consideration. Another issue which should be addressed with a certain degree of urgency is the development of performance requirements for the normal source of power as well as for the secondary source of power.

6.4.4.2 It is expected that detailed requirements in this area will be developed by the International Electrical Commission (IEC) and published as international Standards in due course. However, the meeting considered that the work of IEC should be governed by related Standards and Recommended Practices (SARPs) in Annex 14, Volume I.

6.4.5 Aerodrome retro-reflective markers

6.4.5.1 At present, in accordance with the provisions of Annex 14, Volume I, the application of retro-reflective markers is limited to:

a) taxiway edge markers on taxiways where the code number is 1 or 2 and taxiway centre line edge lights or taxiway centre line markers are not provided (section 5.5.5 refers);

b) taxiway centre line markers on taxiways where the code number is 1 or 2 and taxiway centre line or edge lights or taxiway edge markers are not provided (paragraph 5.5.6.1 refers); and

c) taxiway centre line markers on taxiways where the code number is 3 or 4 and taxiway centre line lights are not provided, if there is a need to improve the guidance provided by the taxiway centre line marking (paragraph 5.5.6.2 refers).

6.4.5.2 The use of retro-reflective films with a high light-reflection factor creates certain possibilities for the application of retro-reflective markers, particularly taxiway edge markers on taxiways where the code number is 3 or 4.

6.4.5.3 Special studies, including laboratory, in-service field and flight testing have been conducted in the Russian Federation with regard to the use of retro-reflective markers for aircraft take-off, landing and taxiing operations. The results of these studies indicated that, in visual meteorological conditions and under certain circumstances, there was a potential to use retro-reflective markers in lieu of approach and runway lighting systems. Furthermore, the results indicated that retro-reflective markers could also be considered for use as supplementary visual aids.

6.4.5.4 The use of retro-reflective markers on taxiways where the code number was 3 or 4 were tested at two airports, one of which was an international airport. At these airports, retro-reflective taxiway edge markers were installed on both the straight and curved portions of the taxiways.

6.4.6 Modification of approach and runway lighting configurations

6.4.6.1 In the United States, evaluations have been undertaken to help determine if modified approach and runway lighting system configurations could be developed that would lower the cost of ownership (acquisition, installation and maintenance costs) and occupy less land area without compromising safety.

6.4.6.2 Presently, simulation evaluations are underway to determine minimum lighting configuration requirements. Evaluation of new lighting sources will be conducted within the next year to determine if new technologies will accomplish the above objectives and/or provide additional visual cues to the pilot. New technologies have the potential of changing the lighting configurations dramatically. These evaluations will be validated by actual flight and field testing at the William J. Hughes Technical Center, Atlantic City, New Jersey. The Technical Center is presently building a reconfigurable test bed which is easily adaptable for various light source technologies and configurations.

6.4.6.3 Recent advances in GNSS capabilities has heightened the prospect of providing category I, II and III approach and landing capabilities at numerous airports. In addition to the considerable expense of installing standard approach lighting systems to support these approaches, many airports do not have the land area that would be required for the installation of such systems. Therefore, additional work will be required to determine if modified approach and runway lighting configurations could be developed.

6.4.7 Visual cueing for helicopter/vertical take-off and landing (VTOL) operations

6.4.7.1 Canada is presently working on the development of approach lighting systems for instrument heliports. With the advancing navigation technology, such as GNSS, and the improving capability of helicopters, there are now many places where it was previously not possible to provide the navigation aids to support instrument approaches. There is an increasing interest of heliport and helicopter operators for such operations. In addition, the tilt rotor is expected to be certificated for civil use in the year 2001. The aircraft is anticipated to have an approach angle in the order of 9 degrees. Consequently, there is a need to consider non-precision and precision approach lighting systems capable of supporting both helicopter and VTOL aircraft operations in an obstacle-rich environment.

6.4.7.2 The present approach lighting systems described in Annex 14, Volume I are 900 m long and were designed to support fixed wing aircraft with a nominal approach path of 3 degrees. Due to land requirements, such systems are not suitable for the conduct of approach procedures in an obstacle-rich environment. Furthermore, improvements in helicopter technology, such as advanced instrument displays and autopilot systems, allow helicopters to conduct instrument approaches at angles significantly greater than 3 degrees.

6.4.7.3 Transport Canada has approved a shortened simple approach lighting system (ODALS) for use at heliports supporting non-precision approaches. While this approach system appears satisfactory, there is to date limited experience in its operational use. Approach lighting requirements to support precision approach operations to heliport are yet to be identified. In this context, there are several issues that will have to be addressed, such as varying approach angles, helicopter approach speed range and deceleration distance required.

6.5 PROPOSED NEW WORK PROGRAMME

6.5.1 In light of the above, the meeting recommended the following tasks for inclusion in a new work programme of the Visual Aids Panel:

ANC Task No.	Work Programme Item	Priority
AGA-9202	1) **Visual aids for advanced surface movement guidance and control systems (A-SMGCS)** a) Co-ordinate the development of visual aids to meet the requirements of A-SMGCS.	A

ANC Task No.	Work Programme Item	Priority
	b) Develop specifications, where necessary, for visual aids to control movements on airports in response to A-SMGCS including variable message signs and selective switching of taxiway centre line lighting.	
AGA-	2) **Visual aids for land and hold short operations** Further development of visual aids for land and hold short operations as required when operational requirements for the planning and implementation of such operations for worldwide application have been developed by ICAO.	A
AGA-	3) **Clarifications to Annex 14 specifications** a) Review and update switch-over time requirements for the barrette centre line type precision approach lighting system. b) Review the use of the "main beam" concept. c) Revise specifications on runway guard lights (light placement should be approximately collocated with the taxi-holding position marking and not related to Table 3-2). d) Review and update specifications on taxiway edge lights.	A
AGA-	4) **Design and monitoring of electrical systems/ reliability of aerodrome lighting systems** a) Review and update Annex 14, Volume I, Chapter 8 specifications on design and monitoring of electrical systems. b) Review and update Annex 14, Volume I, Chapter 9 specifications on maintenance of aerodrome lighting systems with a view to increasing systems reliability. c) Develop related guidance material for inclusion in the appropriate manual.	A/B

ANC Task No.	Work Programme Item	Priority
AGA-	5) **Apron marking/retro-reflective markers** a) Further development of apron markings. b) Review Annex 14, Volume I specifications on mandatory and information markings. c) Development of specifications for retro-reflective markers for take-off, landing and taxiing operations where the code number is 1 and 2. d) Evaluation of the use of retro-reflective markers where the code number is 3 or 4.	B
AGA-	6) **Modification of approach lighting configurations** Study the possibility of modifying the configurations of lighting currently specified in Annex 14, Volume I for precision approach runways categories I, II and III.	B
AGA-	7) **Visual cueing for helicopter/VTOL operations** a) Development of lighting system for non-precision/ precision approaches in obstacle-rich and/or lighting polluted environment. b) Development of lighting for the final approach and take-off area (FATO) for instrument heliport facilities. c) Overall review of lighting requirements for helideck (off-shore) and heliports (surface and elevated).	B

6.6 ACCOMPLISHING FUTURE WORK

6.6.1 The meeting noted that the VAP was established in 1958 and was the oldest panel of the ANC. The panel was established solely to develop a visual aid to overcome undershoot and overshoot problems *viz.* a visual approach slope indicator system (VASIS). Although this task was accomplished in 1960, the panel was allowed to continue further with its terms of reference expanded to cover virtually all the marking and lighting aids needed to facilitate the approach, landing, take-off and surface movement of both aeroplanes and helicopters under different visibility and traffic conditions. During the past thirty-nine years, the panel met on thirteen occasions (including the present meeting).

At each one of these meetings, the panel was able to achieve the goals set by the ANC. One should only refer to Annex 14, Volumes I and II and the *Aerodrome Design Manual*, Part 4 — *Visual Aids* (Doc 9157) to get an appreciation of the specifications and guidance material developed by the panel. These specifications and guidance material have gone a long way in improving the safety and regularity of international civil aviation.

6.6.2 Thus, the continuance of the VAP over the years had enabled the Secretariat to maintain a leading role in the development of SARPs and guidance material related to visual aids. Given the resource situation in the Aerodromes, Air Routes and Ground Aids (AGA) Section, this could not have been accomplished without the support of the panel. In this context, it should be noted that the technical officers of the AGA Section had by tradition had a background in aerodrome civil engineering with limited expertise in visual aids.

6.6.3 The panel presently included nominees of thirteen Contracting States and four international organizations. The present membership, which despite often having differing opinions, still retained the ability to work together constructively to achieve results. Nonetheless, to a certain extent, the six-year gap between the last two panel meetings had proven detrimental to the effectiveness of the panel.

6.6.4 The meeting identified alternative courses for accomplishing the unfinished part of the work programme as well as work on possible new items related to visual aids as follows:

a) keep the panel in existence and establish a revised well-defined work programme (specified time-frames for completion of work programme items should be limited to three to four years); or

b) disband the panel and establish four study groups, as appropriate.

6.6.5 The meeting was advised that, from the Secretariat's viewpoint, the continued support in the field of visual aids provided by the VAP would be a major advantage of maintaining the panel beyond VAP/13. Furthermore, the resources required for the management of four additional study groups are currently not available in the Secretariat.

6.6.6 Like the VAP/12 Meeting, the meeting concluded that there was no other equally suitable alternative means of accomplishing the tasks detailed in paragraph 6.5.1. Shouid the panel be disbanded and a number of study groups be established, it would be necessary to also establish another body to co-ordinate activities of these study groups. A mechanism for this was not currently available in ICAO. It was also pointed out that a change in the modus operandi could delay the completion of the tasks by at least one year given the time needed to set up new groups and to initiate work. Some members of the panel also pointed out that their States might not be prepared to provide as much support for the activities of study groups as they were currently providing to the panel. Consequently, the panel unanimously agreed to recommend to the Air Navigation Commission that the Visual Aids Panel should be retained. However, the meeting also agreed that in the interest of efficiency, the work should be progressed by correspondence to the extent practicable and/or through smaller project-oriented working groups with well-defined terms of references.

6.7 CONCLUSIONS

6.7.1 In light of the foregoing, the meeting formulated the following recommendations:

Recommendation 6/1 — Visual alignment guidance system for heliports

That Item 1 — Visual aids for heliports, be deleted from the VAP work programme until such time as further work on the development of a standard system has been undertaken by States.

Recommendation 6/2 — Visual alignment guidance system for runways

That Item 8 — Visual alignment guidance system for runways, be deleted from the VAP work programme.

Recommendation 6/3 — Switching of lighting aids

That the attention of the Air Navigation Commission is drawn to the need to resolve the issue of switching of lighting aids in order to ensure future safety and efficiency in A-SMGCS.

Recommendation 6/4 — Future of the Visual Aids Panel

That the Air Navigation Commission:

a) agree that the Visual Aids Panel should continue; and

b) establish a new work programme for the panel taking into account the tasks proposed in paragraph 6.5.1 above.

— END —

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